A CLASS COMPEND

OF

PHARMACEUTIC BOTANY

EMBRACING AN ELEMENTARY TREATISE ON THE STRUCTURAL,
MORPHOLOGIC, MICROSCOPIC, PHYSIOLOGIC AND
SYSTEMATIC DEPARTMENTS OF BOTANY

DESIGNED ESPECIALLY FOR STUDENTS OF
PHARMACY AND PHARMACISTS

BY

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WITH A SYNOPSIS AND ORIGIN OF THE NATURAL ORDERS THAT
INCLUDE THE VEGETABLE DRUGS OF THE
U. S. PHARMACOPŒIA, 1890

ILLUSTRATED

BALTIMORE, MD.

1893

Press of
Deutsch Litho'g & Printing Co.,
Baltimore.

PREFACE.

About a year ago the author began a series of magazine articles entitled "STUDIES IN BOTANY FOR THE PHARMACIST" which, owing to varied circumstances, could not, as such, be fully completed. After several numbers of these had appeared and had met with favorable comment, it was suggested that they be so shaped as ultimately to be published in book form; and to that end the task was undertaken.

While I frankly admit that this is not to be regarded as a purely original work, for in modern days scarcely anything can be written without bearing the impress of other minds, nevertheless it is believed that the arrangement and selections will be found favorable features in aiding the student of pharmacy to acquire a conception and understanding of Elementary Botany.

The subject matter is the same as taught in our own college course, and while this work is chiefly designed for the pharmaceutic student, it is also adapted to the needs of the ambitious pharmacist, and is thought to be sufficient in scope for all college and store demands. At the same time it is intended as a handmate to "GRAY'S NEW LESSONS AND MANUAL," without association with which the ultimate profit hoped for cannot possibly be attained.

It is not known by the writer to what extent Botany is taught in our colleges of pharmacy, but he has a clear conception of the *minimum amount* to be known by any one having the assurance to claim himself ever a student of, or a graduate in, that science. In other words, unless one pursues Botanic Studies to the extent of *practically analyzing flowers*, all labor goes for naught, and valuable time will be thrown away. This work, therefore, is supposed to contain the *amount minimum* which, when supplemented with the Manual for analysis, covers about *what is desirable*, so that nothing of moment can be omitted or need be added for the average student.

In the compilation many authors have been consulted. Those to whom I am most indebted are GRAY, WOOD, KILLERMAN, BASTIN (American); BENTLEY, BALFOUR, VINES and BOWER (English). The illustrations are mostly those from "GRAY'S NEW LESSONS," they having been kindly furnished through the courtesy of the American Book Company.

While I am thoroughly conscious of the many imperfections of this edition, which, aided by the solicited suggestions of scholarly friends and critics, I trust in the future to be able to correct; it is, nevertheless, my hope that the book as it is will at least show the light to some who are endeavoring earnestly and honestly to attain a moderate degree of proficiency in Botanic Studies.

BALTIMORE, *Oct.*, 1893.

INTRODUCTION.

IN undertaking a concise and systematic compend having as an object the outlining of a course in Botany especially adapted to the pharmacist, the author is by no means unmindful of the perplexing conditions that must necessarily arise. When it is considered that ours, as a business, is so circumscribing in its apparent necessary demands upon this branch of science, and when we are brought face to face with the myriads of books on the subject in its manifold departments—and these each embracing hundreds of pages—the work of properly selecting suitable material becomes by no means an easy task. Indeed, there are not a few popular educators who disclaim the need to druggists of such a study, even in a limited degree; and while upon such I would not heap too much censure, at the same time I am a pronounced opponent to them in these entertained and advanced opinions. I am convinced that should we leave out altogether the consideration of Botany as a practical utility to our profession, its study will always bring incalculable good in "strengthening and aiding mind development." This we all know has to be done by something. It may be by one or several of the

dead or modern languages; by any or the several branches of mathematics; by political economy, moral philosophy, or by some of the sciences, none of which will have but a questionable bearing upon the future of the pharmacist. Therefore, why not have this "mind training" effected, so far as possible, by application to a subject from which some trite, if not absolutely valuable good can be derived? Viewing the natural conditions from any standpoint whatsoever, I am unable, for the life of me, to imagine its insignificance; to the contrary, I deem it of great practical importance to both the graduate and the non-graduate—all those who propose advancing commensurate with their calling; and thus holding such a tenable position, I shall endeavor in these pages to bring forward that matter alone which will give a modest conception of what is requisite as a stepping-block to the study of our all-important MATERIA-MEDICA. I have always claimed that "*the courses in Botany at Colleges of Pharmacy should be sufficiently comprehensive to equip the student, if he desires at its conclusion, to pursue further investigation of the study by himself; that is, without any assistance other than books, such as manuals, class-books, floras, etc.*"; and, in a measure, these writings are hoped to be of some service toward such an end. Let it be remembered that all I shall have to say will fall comparatively flat unless the reader will verify everything with plant life, and be interested to the extent of making fresh collections illustrative of the subjects

as they are taken up seriatim. So far as it is found consistent, the etymology and pronunciation of botanic terms, frequently so difficult for the novice to master, will accompany the text, thereby trusting that a more accurate and enlightened conception will be afforded than that as set forth in many of our college books. In addition to the collection and close inspection of fresh plant life, I have found the drawing of the respective parts after dissection (and if time be allowed, the painting of these in tinted crayons or water colors, selected and arranged according to nature) to be of admirable assistance towards strongly impressing fixed characteristics, and the adoption of some such plan I would most assuredly recommend to those desiring to make rapid advancement. It is absolutely essential that the would-be botanist, from the very first, should start out with correct and precise bearings, and for this reason we must introduce our subject proper, with its relative position in the scientific world, its divisions, sub-divisions, etc.

CHAPTER I.

THE DIVISIONS OF SCIENCE.

The phrase *Natural History,* though at first acquaintance giving an impressive halo of vastness, is to a little extent modified when we define it as meaning purely "*the History of Nature.*"

Under this heading is to be included and studied:

1. THE EARTH ITSELF, embracing all things thereon which are earthy. These do not possess life; are inanimate, such as air, water and minerals.

2. THE LIVING BEINGS that exist upon the earth, fashioned by innate processes. These possess life or vital force; hence are animate, such as plants, insects and animals.

The *first* department constitutes what is known as the **Inorganic World or Creation,** *and comprises* solely the MINERAL KINGDOM, while the *second* is known as the **Organic World or Creation,** and comprises the ANIMAL AND VEGETABLE KINGDOMS.

The differences between these two great departments are evidently extreme, as the one deals alone with dead and the other with living matter.

The *former*—INORGANIC—on the one hand, treats solely of material which is unorganized;

that is, without distinction of parts or organs. To illustrate: An ordinary piece of stone may be divided into many fragments, but each portion will always retain an identity with the original mass, and so be recognized as a piece of stone; hence a uniform sameness pervades the whole body. This entire subject, in its full comprehensiveness, forms the basis of Chemistry, Geology, Mineralogy, etc.

The *latter*—ORGANIC—on the other hand, includes alone all that which is composed of *organs*—parts differing from one another, which go to make up individuals in their entirety. These owe their existence to a preceding one like itself, *i. e.*, a parent—was not simply formed all at once, as in the case of the stone or minerals, but increases in size gradually by self-inherent powers till maturity is reached, when, after a more or less quiescent state, it by equally natural laws dies and decays, thus returning whence it came. To illustrate: In the case of higher typed animals and plants that are composed of parts, organs, we can dissect and subdivide these indefinitely, but none of the separate portions could rightfully be designated with the name which the complete object bears; thus, a leg of a horse or the leaf of a tree can neither be termed a horse nor a tree. Consequently these component parts are true organs, and are unlike all other dissimilar organs which the horse or tree may possess.

It is not difficult, then, to recognize the pure

and typical ORGANIC from the INORGANIC CREATION, when we bear in mind that members of the former have the following characteristics, none of which the latter possess: 1. *Parentage*; 2. *Development*; 3. *Growth methods*; 4. *Assimilation*; 5. *Physiological processes*; 6. *Morphological processes*; 7. *Period of life*; 8. *Reproductive powers*. At the same time, while we, in all of our proposed writings, regard these as absolute facts, it may be interesting, but must be accepted as purely speculative, that there are some naturalists who even claim there is no line of demarcation between the lowest or Mineral Kingdom and the medium or Vegetable Kingdom, and positively affirm that *simple organisms can be and are formed out of inorganic matter*. With this view we are not in accord; hence it does not concern us, only so far as to make casual mention of it.

The **Inorganic World**, as already mentioned, comprises solely the MINERAL KINGDOM, and for that reason, beyond merely defining and stating its relative position, it possesses little of interest to the botanist; but to the chemist, geologist, mineralogist, etc., it becomes the main important working field. From the hands of such sciences we have received intelligent interpretations of the wisdom of numerous natural laws, otherwise inexplicable, and have had revealed the many hidden and unwritten secrets which serve as the only true and reliable history of the Earth from its early inception to the present day.

The **Organic World** includes, as has already been stated, the two great living systems, viz.: 1. THE ANIMAL KINGDOM, and 2. THE VEGETABLE OR PLANT KINGDOM. The *one* is studied under the caption of Zoology (Gr. ζῶον, animal + λόγος, history), and, in a treatise like this, has to be mentioned only incidentally. The *other* is called Botany (Gr. βοτάνη, a plant), and is more liberally defined as the *History of Plants*. This is at present to be our study and the subject of the following pages.

It must not be supposed, however, that these two great kingdoms of the organic world are thoroughly inseparable, as our treatment might suggest, for they merge so closely into one another that frequently it is anything but easy to accurately determine whether certain living things belong to the one or the other. It is not difficult to distinguish the higher ordered animals on the one side from the correlative plants on the other, as the lion from the oak, for instance; but when we descend to the minute forms of each kingdom, it becomes exceedingly troublesome to assert which is an animal and which is a plant. Indeed, the ordinary characters of animal life are possessed also by vegetables, and therefore is it all the more puzzling often to say when animal life ceases and vegetable life begins.

Many minute forms which have occupied the attention of microscopists, and which for a long time have passed undisputed for animals, are now proven to belong to the plant system, and there are

still many which the zoölogist and botanist must, for a time to come, accept as common property. Until quite recently many of our best investigators claimed there to be organisms which, at certain periods of their lives, were plants and at another became animals. Thus the *Æthalium*, at first producing naked, motile protoplasmic bodies, had these to coalesce, forming amœboid masses of protoplasm which were able to creep over surfaces upon which they grew, and had the power to take internally solid matters and to digest them, just like the true amœba of the animal nature; and in this stage it was considered an *animal.* Later on, this plasmodium becomes quiescent, divides into numerous small portions, each clothed with a cell wall of cellulose, thus becoming a spore, and in this stage is considered *a plant.* It is now recognized by the best authorities as belonging solely to the Vegetable Kingdom, because De Bary and many others in their later researches have clearly proven that this amœboid condition is of frequent recurrence in certain stages of many organisms, of the plant nature of which there can be no possible question. Again, the various species of Volvox are by Stein and others considered undoubtedly as animals, while other authors of equal standing affirm them to be true plants. All this irregularity is confined to the low miscroscopic organisms and, as might have been inferred, result from the fact that there are certain ones of these that possess both kinds of characters—those distinctive of *animal*

life and others indicative of *plant life.* Haeckel proposes the grouping of all such under the head of a THIRD KINGDOM, which he denominates PROTISTA KINGDOM, prō-tĭs′tȧ (Gr. πρώτιστος, first), so named in allusion to its consisting of the first or primitive earthly life forms.

These being the facts, you might quite properly ask how, then, is one to recognize these very objects of which we are expected to know so much? It might be parenthetically remarked, however, just here, that nearly all plants and drugs with which it is necessary for the pharmacist to have dealings are of the higher type, and these have enough specific differences by which they can readily be distinguished from anything else, by even the inexperienced. At the same time it will not be amiss to enumerate the leading characteristics which are of service in differentiating a plant from an animal.

1. PLANTS are the connecting link between the inert world—minerals—and the animal economy. They prepare from the earth, air and water all food with which to build up animal life, and these alone have the power of converting mineral or inorganic matter into organic. This animal life in turn lives on organic matter, and when death and decay takes place, it is handed back to the inorganic world as unorganized material for reabsorption by plants, thus always forming a complete cycle.

2. PLANTS AND ANIMALS act differently upon the atmosphere during assimilation. The *former* inhale carbon dioxide of the air or water in which-

ever they happen to be growing, and unite the carbon thus obtained by the decomposition of CO_2 with the elements of water to form starch or other carbohydrates, and restore the liberated oxygen to the atmosphere or water. The *latter*, on the contrary, take into their tissues free oxygen and give out carbon dioxide, this being the result of the combination of the superfluous carbon in the animal system with the oxygen which has been inhaled. To illustrate this, we can enclose a plant under an air-tight receiver containing an atmosphere of CO_2 and expose this to direct sunlight, and it will be found in due time to contain a very small per cent. of the original CO_2 gas, but instead to have considerable O. Upon introducing into this globe a lighted taper, it would at once burn much more brilliantly. On the contrary, should the receiver be filled with O in the presence of animal life, we would have it replaced by CO_2, in which the lighted taper would be extinguished.

3. PLANTS have little if any voluntary movements, excepting *Sensitive Plants*, *Pitcher Plants*, *Venus Flytraps*, *etc.*, while most of animals are unlimited in that power, saving such as *Barnacles*, *Polyps*, etc., which are almost stationary. This mobility on the part of animals affords opportunity to seek and select food, a privilege which plant life cannot enjoy. A wise provision of nature is this; inasmuch as animals are not at all creative of food, they must migrate for it, while plants are creative

and can remain in one spot, accepting whatever comes in contact with them, whether that, in a degree, be favorable or unfavorable, and thus utilize the same for their own development. Evidently, then, these plants are nourished from *without* and animals from *within.*

4. PLANTS as well as animals are composed of cells, but those of the latter do not develop upon their exterior any substances differing from the internal cell protoplasm: in other words, the entire animal cell is homogeneous and without a cell wall, which is invariably more dense or refractive than the other portions of the cell; the former, or plants, have, on the contrary, cells with *walls* which enclose the less refractive protoplasm. These *walls* consist purely of cellulose, $C_6H_{10}O_5$, while the remainder of the living *plant cell* and the entire *animal cell* generally contains six elements, of which four, C, H, N, O, occur in greater, and two, P and S, in lesser quantity.

It was also for a long time held that the presence of *starch* was characteristic of plants alone, but latterly starch, or an isomeric substance of close resemblance, has been found in animal tissue, in consequence of which this point is of little diagnostic value.

In the scale of rank it may be added that the three kingdoms have each its intrinsic position, the MINERAL being the *lowest*, the VEGETABLE being *intermediate* or *medium*, and the ANIMAL being the *highest.*

CHAPTER II.

Having now defined our relative position in Nature's History, let us turn our attention specifically to the VEGETABLE KINGDOM, which is comprehended in its many shapes and forms under the one descriptive science called Botany. While this has several higher and restrictive departments in which specialists absorb their eventful lives, and that, too, without gaining much knowledge of the unknown, at the same time for us there remains the general divisions of Elementary Botany, made for convenience and simplicity sake, and these we will now proceed to discuss.

1. **Structural Botany or Organography** (Gr. ὀργᾶνον, implement + γράφος, writing about).—The study of plants, as to their organs or parts composing them, and with which they do their work, as root, stem, leaves, etc.

2. **Morphological Botany** (μορφή, form + λόγος, history).—The study of these same organs, when metamorphosed into different forms and uses from the normal; thus the comparison of a sepal, petal, or a bud-scale with an ordinary leaf. This is also called COMPARATIVE ANATOMY OF PLANTS.

3. **Microscopical Botany** (μικρός, small + σκοπός, a view).—The study of minute parts by the

aid of the microscope; to observe of what and how the parts are made. This is also called VEGETABLE HISTOLOGY.

4. **Physiological Botany** (φύσις, nature + λόγος, discourse).—The study of the history of vegetable life; the functions of various organs; minute structure and method of growth.

5. **Systematic Botany** (σύν, with + ἱστάνια, to place).—The study of plants in relation to principles upon which they are to be classified or arranged with reference to their degrees of mutual affinities or relationship. Thus, all the kinds of plants known, when classified according to their various degrees of resemblance or difference, constitute a general "*system of plants*," while what is known as a *Flora* is such an account, but only embraces the plants of some particular country or district.

In addition to these five great subdivisions we, in a general way, can study plants with reference to their distribution in time and space, giving rise to PALEONTOLOGICAL and GEOGRAPHICAL BOTANY; or again, as *Applied Botany*, in reference to human fancy and needs, giving rise to *Floricultural, Agricultural, Horticultural, Pharmaceutical and Medical Botany*. In taking up now the whole plant system in its entirety, we soon find that we can divide them into two great *Sub-kingdoms*, viz.:

I. **Sub-kingdom Cryptogamia**, krĭp′tō-gā′-mĭ-ȧ (Gr. κρυπτός, hidden + γάμος, marriage), *i. e.*, having an obscure or hidden mode of fertilization. These reproduce by minute bodies called

spores, which have no embryo and produce no visible flowers; therefore are also called *Flowerless Plants*. *Cryptogamous Plants* (krĭp-tŏg′ā-mŭs) are, in turn, divided into the following series or branches:

1. THALLOPHYTA, thăl′lō-fī′ta (Gr. θαλλός, young shoot + φυτόν, a plant).—Here we have no differentiation of the plant body into root, stem and leaf. These are subdivided into

(a). *Myxomycetes*,
(b). *Schizophyta*,
(c). *Algæ*,
(d). *Fungi*,
(e). *Lichens*,
= Classes.

2. BRYOPHYTA, brī-ŏf′ĭ-tȧ (Gr. βρύον, moss + φυτόν, a plant).—Here we notice distinct cellular tissue, as well as leaves, stem and root hairs. These are subdivided into

(a). *Hepatica*,
(b). *Musci*,
= Classes.

3. PTERIDOPHYTA, tĕri-dŏf′ĭ-ta (Gr. πτερίς, πτερίδ, fern + φυτόν, a plant).—These are all chlorophyll-bearing, are neither parasitic nor saprophytic, and are termed vascular cryptogams. Are subdivided into

(a). *Equisetineæ*,
(b). *Filicineæ*,
(c). *Lycopodinæ*,
= Classes.

II. **Sub-kingdom Phanerogamia**, făn′ē-rŏ-gā′mĭ-ȧ, (Gr. φαίνειν, visible + γάμος, marriage).—

Having a visible mode of fertilization, *i. e.*, by visible flowers; hence, also called *Flowering Plants*. These reproduce by seeds containing an embryo with one or more cotyledons.

Phaenogamous, phenogamous (fē-nŏg′ă-mŭs) plants have their organs of reproduction developed and visible, inasmuch as the flowers contain stamens and pistils, and are divided into two classes:

1st class: GYMNOSPERMÆ, jĭm′nō-spĕr′mē (Gr. *γυμνός*, naked + *σπέρμα*, seed).—These have their seeds exposed or unprotected, consequently fertilization takes place by immediate contact of pollen with ovules. These are subdivided into

(a). *Cycadeæ*,
(b). *Coniferæ*, = Sub-classes or orders.
(c). *Gnetaceæ*,

2d class: ANGIOSPERMÆ, ănjĭŏ-spĕr′mē (Gr. *ἀγγεῖον*, a vessel + *σπέρμα*, seed).—Here the seeds are protected in a seed-vessel, *i. e.*, ovary. This in turn is subdivided into

(a). *Monocotyledons*, mŏn-ŏ-kŏt-ĭ-lē′dons (Gr. *μόνος*, single + *κοτυληδών*, cavity or seed leaf).
(b). *Dicotyledons*, dī-kŏtĭ-lē′-dons (Gr. *δι*—*δις*, twice or two + *κοτυληδών*, cavity or seed leaf).
Sub-classes or orders.

In order that we may have a proper conception of the magnitude of the Plant Kingdom, we must bear in mind that there are over two hundred thousand distinct kinds of plant life belonging to it. About two hundred thousand have been studied

and named. Of this number, one hundred thousand belongs each to Cryptogamia and Phanerogamia. The latter has twenty thousand Gymnospermæ and eighty thousand Angiospermæ.

It is with a portion of this eighty thousand that the science of medicine and pharmacy is mostly concerned, as some four hundred are our stock of vegetable remedial agents. In addition to these, we have a few from the twenty thousand, such as Abies balsamea, Abies Canadensis, Abies excelsa, Pinus australis, Juniperus communis, Juniperus Virginiana, Juniperus Sabina, etc. From the one hundred thousand Cryptogamia, we only have six that are officinal: Cetraria islandica, Chondrus crispus, Aspidium filix-mas, Lycopodium clavatum, Ustilago maydis, and Ergota.

Our main study, consequently, is to be with the flowering plants, and these, fortunately, have distinct as well as characteristic organs which, for the sake of convenience, can be divided into two classes:

1. *Vegetative*, or those which imbibe, circulate and elaborate food, viz., roots, stems, leaves and hairs.

2. *Reproductive*, or those whose province it is to propagate and reproduce the species, viz., flowers, fruits and seeds.

The consideration, therefore, of these organs form one of our divisions of Botany, namely, Structural Botany, which occupies by far the most of our general subject, and this we will discuss in several of the following chapters.

Recapitulation.

NATURAL HISTORY =

- I. **Inorganic World** = MINERAL KINGDOM = Chemistry, Geology, Mineralogy, etc.
- II. **Organic World** =
  - I. ANIMAL KINGDOM = Zoology.
  - II. VEGETABLE or PLANT KINGDOM = Botany
    - 1. Structural
    - 2. Morphological
    - 3. Microscopical
    - 4. Physiological
    - 5. Systematic
    - I. Cryptogamæ
    - II. Phanerogamæ
      - I. Gymnospermæ
        - 1. Cycadeæ,
        - 2. Coniferæ,
        - 3. Gnetaceæ.
      - II. Angiospermæ
        - (1). Monocotyledons,
        - (2). Dicotyledons.

ORGANS =

- VEGETATIVE = Roots, Stems, Leaves, (Hairs).
- REPRODUCTIVE = Flowers, Fruits, Seeds.

PART I.

STRUCTURAL BOTANY; OR, ORGANOGRAPHY.

CHAPTER III.

THE FLOWER IN GENERAL.

The Flower is not only "a thing of beauty," but also has a far more significant mission in being designed as the immediate agent through which seed are produced and thereby the propagation of species effected. By a minute study of its various parts and the many differences that each part is liable to assume, are we enabled to arrange and classify the plant system. In the "Natural System of Classification" the flower, above all, holds the "key to the situation." From the magnitude, then, of its importance we are rightly justified in assigning to it a place pre-eminent. And by giving it, thus, our earliest consideration, the greatest possible opportunity is afforded for comprehending its detail, inasmuch as continued reference and analysis cannot but help yielding that requisite familiarity without which all future study in this line will be of little avail.

If we take up a typical bloom (Buttercup, Flax, Geranium, Petunia or Spring-Beauty), as in Fig. 1, and carefully dissect it, we will find it to consist of six distinctive parts or organs, all differing very much from one another, and known, respectively (going from outside inward), as CALYX, COROLLA, STAMENS, PISTILS, TORUS, PEDUNCLE. The first two sets are considered *enveloping organs*, the next two *essential organs*, and the last two I denominate *supporting organs*. Again, the first four organs appear under many variations; are, as a rule, in multiples, *i. e.*, made up of several like parts or units, and each kind, constituted thus, represents its characteristic system called *whorls;* on the other hand, the last two have few varied forms, and each has only one fundamental component part.

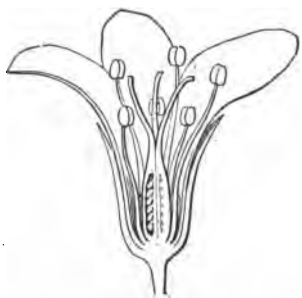


FIG. 1.

1. **Calyx,** kā′lĭks (Gr. κάλυξ, a shell or husk).—This is the outside set of leaves, usually green or foliaceous, and encloses the other parts as a cup or chalice. (See *a*, Fig. 2.) Each separate part or leaf of the calyx is called a SEPAL, sē′pal (L. *sepalum*, in imitation of petalum, a petal or a plate), and these may have their edges distinct or united. Sometimes these SEPALS, instead of being green and leaf-like, become highly colored

or showy (Anemone, Columbine, Hepatica, Iris, Lady's Slipper, Larkspur, Lily, etc.); then they are said to be *petaloid* (Gr. πέταλον, petal + εἶδος, resembling). Flowers of the Compositæ have *calyx tube* united to the ovary, while its *limb* is converted into a downy, hairy or scaly crown called the Pappus (Gr. πάππος, grandfather, in resemblance to his gray hairs); by this the wind wafts the ripened fruits of many plants (Dandelion, Lettuce, Teasels, Thistles, Valerians, etc). If calyx remains till fruit is fully ripe, it is said to be *persistent;* if it falls off earlier than this = *deciduous*.

2. **Corolla**, kŏ-rŏl'lȧ (L. dim. of *corona*, a crown).—This is the next set of leaves inside of the calyx, is generally highly colored, and may occur in one or more circles having the edges distinct or united. (See *b*, Fig 2.) This alone is what the laity term *the flower*, and each separate part or leaf is called a PETAL, pĕt'al (Gr. πέταλον, a leaf). These sometimes become green, like ordinary leaves or *sepals*, when they are said to be sepaloid, resembling sepals (Cobæas, Asclepiadaceæ.) While *petals* are usually all blade or shaped like a leaf, yet sometimes different segments receive distinctive names. When the lower part is narrowed = *the claw*, the spreading, broad upper part = *the limb*, and when there is a little fringe of variegated colors at the junction of the two = *the corona*. Each one of these parts generally differ slightly in color (Passion flowers, Pinks). The calyx may exist without the corolla, but the converse is not

true. When both are present they are considered, collectively, as the *floral envelope* or the PERIANTH, pĕr′ĭ-ănth (Gr. περί, around + ἄνθος, flower). This term is descriptive, being specially used when the two *whorls* are so similar as not to be easily distinguished (Tulip, Lily, Endogens generally) and where only one envelope exists (Elm, Phytolocca, etc.).

3. **Stamens,** stā′mĕn (L. *stamen*, thread) are thread-like organs situated just within the perianth; they are the male organs, and vary in number from one to a hundred or more, but the usual number is five or a multiple. (See *c*, Fig. 2.) These are termed, when hair-like = *capillary* (Grasses); when thread-like = *filiform* (Rosaceæ); when petal-like = *petaloideous* (Nymphæaceæ): when forked = *toothed* (Onion); when additions grown to it = *appendaged* (Milkweed); when unbranched = *simple*—most common (Geranium); when several divided = *branched* (Recinus). All of these various forms are but designs towards specific modes of pollination. Taken as a whole, they are called the ANDRŒCIUM, ăn-drē′shĭ-ŭm (Gr. ἀνήρ, ἀνδρός, man, stamen + οἶκος, house).

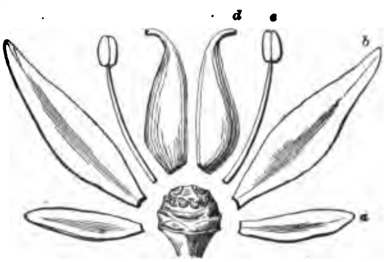


FIG. 2.

4. **Pistils,** pis′tĭl (L. *pistillum*, a pestle), originating from likeness of the perianth to a druggist's

mortar and the pistil to its pestle (Crown Imperial Lily).—This is the innermost set of organs, and usually occupies the center of the bloom. (See *d*, Fig. 2.) They are sometimes numerous, again few, or may be but one. These are the female organs and, collectively, are called GYNÆCIUM, jĭn'ė-sī'ŭm (Gr. γυνή, woman, pistil + οἶκος, house).

5. **The Torus** (L. *tŏ'rŭs*, an elevation) or **Receptacle,** rė-sĕp'tȧ-k'l (L. *receptàculum*, a repository), is the enlarged upper end or apex of the flower-stalk, peduncle or pedicel. (See central nodule, Fig. 2.) From this the first four sets of organs grow, and by it are held up or supported.

6. **The Peduncle,** pė-dŭn'k'l (L. *dim. pes. pedis*, a foot), is the entire remaining portion of the flower-stalk or stem; the downward continuation of the central nodule (Fig. 2). If any leaves on this they are very small and changed in form; being called *bracts*. The simple peduncle bears a single flower, but it may be divided into branches, each bearing a flower. Each branch, then, is called a PEDICEL, pĕd'ĭ-sĕl (L. *pediculus, dim. pes. pedis*, a little foot).

THE PLAN OF THE FLOWER.

While what has been said as to the parts of the flower is true, and while these parts are quite distinctive and for the most part easily recognized, yet flowers exist in so many metamorphosed forms that under these changed conditions their study becomes intricate and perplexing.

THE TYPICAL FLOWER, however, is the one best to work on first, and as such it must possess several attributes. Carefully study Figs. 1 and 2, as they embody all the requirements for such a flower. Thus it must be:

1. **Complete,** having the first four sets of organs arranged in as many concentric circles.

2. **Perfect** (hermaphrodite), having both kinds of essential organs (stamens and pistils).

3. **Regular,** having the organs of same circle alike in size and shape.

4. **Symmetrical,** having the same number of parts or organs in each set or circle. This is known as Numerical Plan, which is either in fives, threes (rarely fours or twos), or multiples of them.

5. **Alternating,** having each set or whorl of organs standing over the intervals of one another. The *petals* between the *sepals;* the *stamens,* when of like number, between the *petals;* or if twice the number, the outer set between the *petals* and the inner set in front of the *petals* (Trillium), and the *pistils* alternate with these. This demonstrates the identity of the *circles of the blossom* being but the *whorls of ordinary leaves.* (See Fig. 3.)

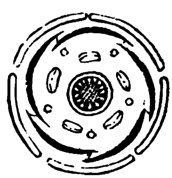


FIG. 3.

6. **Distinctive,** having the organs all disconnected and free from each other. Flowers, such as the Crassula and the Flax, are good examples answering to the typical kind, but decidedly the most of flowers do not conform to this type, although the tendency towards it is universal.

CHAPTER IV.

THE CALYX AND COROLLA IN PARTICULAR.

MODIFICATIONS OF THE TYPE.—The deviations from the pattern flower are for the most part philosophical and for special utilities. These are, however, very numerous, but are well classified for study as follows:

1. **Incomplete Flowers,** opposed to *complete*.—These either want one or both of the floral envelopes:

(*a*) NAKED, having neither floral envelope (Lizard's-tail).

(*b*) APETALOUS, having no corolla (Anemone).

2. **Imperfect Flowers,** opposed to *perfect*.—These are without either stamens or pistils, *i. e.*, some blooms contain stamens but no pistils, and are then called STAMINATE, STERILE or MALE FLOWERS, while others contain pistils but no stamens, and are called PISTILLATE, FERTILE OR FEMALE FLOWERS.

(*a*) MONŒCIOUS, mō-nē'shŭs (Gr. *μόνος*, single + *οἶκος*, house).—When both kinds of flowers, each of a single sex, are produced by the same individual plant (Castor-Oil Plant, Oak).

(*b*) DIŒCIOUS, dī-ē´shŭs (Gr. δι, two + οἶκος, house). —When these two kinds do not occur on the one individual plant, mixed here and there indiscriminately, but instead thereof we have separate plants bearing nothing but staminate flowers and others bearing only pistillate flowers; thus among trees we recognize the former as *male* and the latter as *female* trees (Hemp, Moonseed, Poplars, Willows).

(*c*) POLYGAMOUS, pō-lĭg´ȧ-mŭs (Gr. πολύς, many + γάμος, marriage).—When *perfect*, *staminate* and *pistillate* flowers are all produced on the same individual plant (Maple, etc.).

3. **Irregular Flowers,** opposed to *regular*.—Where the members of some or all of the circles vary in size or shape among themselves (Aconitum, Catalpa, Labiatæ, Leguminosæ, Violets). (See Fig. 4, the flower of Aconitum Napellus.) The four larger leaves and the upper left-hand hood are sepals; the five smaller points are petals, which consist of three lower and two upper (nectaries) covered by the hood. This plainly shows a great difference from the normal, as illustrated in Figs. 1 and 2.

FIG. 4.

4. **Unsymmetrical Flowers,** opposed to *symmetrical*.—When some or all of the flower circles differ in the number of their members (Larkspur, Monks-hood).

Many modifications of the normal type result from a union of the various organs of the flower. Of this growing together we have two kinds, viz.:

1. **Cohesion or Coalescence,** the joining of the members of the same circle by their contiguous margins (Mallows, Morning Glory, Pink, Poppy, Stramonium).—Contra to *distinct.*

2. **Adhesion or Adnation,** where the adjacent or unlike parts are united to one another—one whorl to another (Apple, Phlox, Wintergreen).—Contra to *Free.*

FIRST, BY COHESION we have the following named abnormal conditions:

(*a*) GAMOPETALOUS (Gr. γάμος, united) or Monopetalous (Gr. μόνος, single).—Where the petals are united by their edges (Morning Glory). See Fig. 5, which is a funnel form corolla of the common Convolvulus detached from its polysepalous calyx (Ger. *sympetalous*). Polypetalous (Gr. πόλυς, many) or Choripetalous (Gr. χωρίς, disjoined) is a counterpart word, and means separate petals (Ger. *apopetalous*).

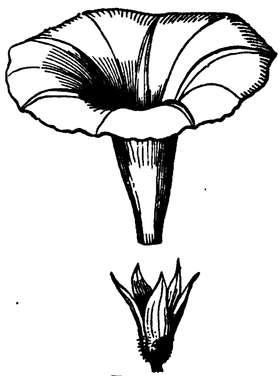


FIG. 5.

(*b*) GAMOSEPALOUS or Monosepalous. — When sepals are united by edges. *Polysepalous* or *Chorisepalous* is the counterpart word, meaning sepals separate or many. (Ger. *synsepalous, aposepalous.*)

The general outline or configuration of blooms serve frequently to enable botanists to give, at sight, some intelligent evidence of the *place where* in the Natural System they belong. In pursuance of this fact we have assigned specific names to characterize these particular shapes, which in turn facilitates greatly ready comprehension.

OF THE REGULAR FLOWERS with gamopetalous corolla, we have (see Fig. 5):

1. **Rotate Corolla** = Wheel-shaped. — When the petals spread out at once from the point of their attachment on the torus without any tube whatever (Bittersweet, Potato).

2. **Salver Corolla** = Salver-shaped. — When a flat, spreading border is raised on a narrow tube, diverging from same at right angles (Cypress, Ipomœa, Petunia, Phlox).

3. **Campanulate Corolla** = Bell-shaped. kăm-păn′ŭ-lāt (L. *campanula,* little bell; *dim.* of *campana,* bell).—Where a short and broad tube widens upward in the shape of a bell (Canterbury-bell, Harebell).

4. **Funnel Corolla** = Funnel-shaped.—Spreading gradually at the summit of a tube and narrowed below in the shape of a funnel (Morning Glory, Stramonium). (See Fig. 4.)

5. **Tubular Corolla** = Tube-shaped. — When prolonged into a tube spreading but little at the border (Honeysuckle Corolla, Pink and Stramonium Calyx). Such corollas, being gamopetalous, have their different portions distinctively

named. Thus the tubular portion is called the *Tube*, the spreading portion above = the *Border or Limb*, and the junction of these two = the *Throat*.

OF THE IRREGULAR FLOWERS, either with polypetalous or gamopetalous corolla, we have (see Fig. 4):

1. **Papilionaceous Corolla,** pȧ-pĭl′yō-nā′shŭs (L. *papilio*, a butterfly), from the flower's resemblance, in shape, to that insect (Clover; Leguminosæ—Pea, Locust). The five petals here have special names.

THE STANDARD or BANNER (Vexillum) is the largest and uppermost petal, and, being external in the bud, is wrapped around the other petals.

THE WINGS (Alæ), the pair of side petals, differing in shape and much smaller than the *standard*.

THE KEEL (Carina), the two lower and smallest petals.—These enclose the stamens and pistil. Named from resemblance to a boat's keel, but in reality is much more like the prow (Leguminosæ).

2. **Labiate Corolla** = Bilabiate or two-lipped (L. *labium*, lip).—These are gamopetalous, on the plan of five, and shape due to unequal union of petals (Labiatæ, Mints, Snapdragon). The two uppermost petals form the *upper lip* and the two side and lower form the *lower lip*. The marginal indentations and the *alternation* of circles reveal this composition.

3. **Ligulate Corolla** (L. *ligula*, little tongue).—This belongs mainly to the order of Compositæ, where they constitute the *ray florets*. The *disk*

florets are strictly gamopetalous, while these are decidedly polypetalous. The marginal notches show the plan of the flowers (Asters, Coreopsis, Daisies, Sunflower).

SECOND, BY ADHESION we have very many changes made in the typical flower. It must be remembered that here, as in cohesion, the parts are not formed and then conjoined, but they grow united from the beginning. In the cherry bloom have sepals, petals and stamens consolidated to a certain point. In Purslane all four whorls are consolidated to their middle. In Hawthorn consolidation extends entirely over ovary, and petals and stamens are adnate to the calyx even beyond. In Cranberry all parts seem to arise from the top of the ovary.

To express concisely the relation of all the other organs to the pistil, we use the following terms:

1. **Hypogynous**, hī-pŏj'ĭ-nŭs (Gr. υπό, under + γυνή, pistil).—When all parts are *free* from one another and take their origin from under the pistil, same as OVARY SUPERIOR OR FREE (Flax, Jeffersonia, Violet).

2. **Perigynous** pĕ-rĭj'ĭ-nŭs (Gr περί, around + γυνή, pistil).—When petals and stamens grow from the calyx or pistil at a point near the middle of the ovary, same as OVARY PARTLY INFERIOR (Cherry, Phlox, Plum).

3. **Epigynous**, ĕ-pĭj'ĭ-nŭs (Gr. ἐπί, upon + γυνή, pistil).—When all the parts appear to grow from the summit of the ovary, same as OVARY INFERIOR (Apple, Caraway, Pear, Sunflower).

CHAPTER V.

THE STAMENS IN PARTICULAR.

Andrœcium is the technical and convenient name used when speaking of the stamens as a whole — Staminate system. These are the male organs of reproduction, and each stamen when complete consists of two distinct parts, viz., *Filament* and *Anther*.

1. FILAMENT. This is a long slender stalk or standard (see the slender portions of Figs. 6, 7, 8), but it is not essential, and when absent the stamen is said to be *Sessile*. These are generally *white*, but may be highly colored like the perianth; thus, *blue* in Spiderwort, *yellow* in some Ranunculus, Œnothera; *black* in some Poppies; *red* in Fuchsia.

2. ANTHER.—This is an enlarged nodule at the apex of the stamen (see Figs. 6, 7, 8); it is absolutely essential, inasmuch as it contains the male germinating material called *Pollen*. These, when young, are *greenish*. When mature, generally *yellow*, but may be *dark purple* or *black*, as in Poppies; *orange* in Eschscholtzia; *purple* in Tulip, *red* in Peach.

Insertion.—The Stamens generally go with the petals.

1. HYPOGYNOUS — inserted on the receptacle under the pistil. This is the normal way and all others are deflections (Poppy, etc.).

2. PERIGYNOUS—inserted on the calyx, but about midway up the ovary = pistil (Apple, Cherry).

3. EPIGYNOUS—inserted apparently on top of the ovary (Fennel, Madder.)

4. EPEPETALOUS—inserted on the corolla (Phlox, Morning Glory, etc.).

5. GYNANDROUS — inserted on (grows together with) the *style* (Orchis, etc.).

Relation:

First, as to Filaments.

1. DISTINCT.—Here all are separate, none united; this is normal.

2. MONODELPHOS (Gr. μόνος, single + ἀδελφός, brotherhood).—Here all the *filaments* are united into one set or tube = Lobelia, Lupini, Malvaceæ.

3. DIADELPHOS (Gr. δι, twice + ἀδελφός, brotherhoods).—Here the filaments are united into two sets or clusters (Hyperium, Pea, Squirrel-corn.)

4. PENTADELPHOS (Gr. πέντε, five +).—Here have five sets (American Linden, Hyperium).

5. POLYADELPHOUS (Gr. πολύς, many+).—Where there are many sets (St. John's wort).

Second, as to Anthers.

1. DISTINCT. — Here all are separate, none united.

2. SYNGENESIOUS.—Here all the anthers are united into one ring or tube (Compositæ, Lobelia, Violets.)

Numeration.—When less than twenty they are known as *definite*, and we may express the number directly or use the names of the classes as given by Linnæus, *i. e.*, Greek numerals, viz.:

MON-ANDROUS.—When the flower has only one stamen (Hippuris).

DI-ANDROUS.—When the flower has only two stamens (Lilac).

TRI-ANDROUS—three stamens (Valerian).

TETR-ANDROUS—four stamens (Scabious).

PENT-ANDROUS—five stamens (Primrose).

HEX-ANDROUS—six stamens (Geranium).

POLY-ANDROUS — many stamens; more than a dozen (Anemone, Buttercup).

The rule is that in the same flower the stamens are of the same length. We have two notable conditions which are exceptions.

1. DIDYNAMOUS, dī-dĭn′ȧ-mŭs (Gr. δι, twice + δύναμις, power).—Having four stamens, two long and two shorter (Gerardia, Trumpet Creeper).

2. TETRADYNAMOUS, tĕt′rȧ dĭn′ȧ-mŭs (Gr. τέτρα, four +). — Having six stamens, four long and two short (Cruciferæ).

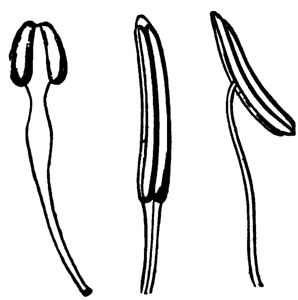


FIG. 6. FIG. 7. FIG. 8.

The Anther has some variations which are of significance.

1. ADNATE.—When the Anther is attached by the entire face of

one side. Here the filament is adnate the whole length of the Anther (Magnolia). (See Fig. 7.)

2. INNATE.—When the Anther is attached by its base to the apex of the filament (Saxifrage.) (See Figs. 6, 7, 8.)

3. VERSATILE.—When the Anther is fastened by its longitudinal center to the apex of the filament, thus admitting of a swinging or hinging movement (Agave). (See Fig. 8.)

The first and third kind of Anthers may be with these conditions:

INTRORSE (L. *introrsus*, inward turned).—When lines of dehiscence look toward the pistil (Magnolia, Violet, Water-Lily).

EXTRORSE (L. *extrorsus*, outward facing).—When lines of dehiscence look toward the Corolla (Iris, Tulip).

THE CONNECTIVE, which is the filament prolonged between the two lobes of the anther through their entire length, may be narrow or very broad (Asarum, Calaminth, Sage). As the stamens are but infolded leaves, each margin of the leaf forms an anther lobe, consequently they are called *two-celled*. The *pollen*, however, begins to form at each end of either lobes simultaneously, and as these may never become confluent, we have *four cells* resulting; hence each lobe is *bilocellate* (Moonseed). On the contrary, Anthers, by confluence or suppression, may become *one-celled* (Malvaceæ, Monarda, Pentstemon).

DEHISCENCE is the splitting open of anthers to

discharge their pollen. We have four ways: 1. Longitudinal = lengthwise the anther (Agave, Saxifrage). 2. Transverse = crosswise the anther (Alchemilla.) 3. Valvular = opens laterally by lids (Barberry, Sassafras, Spice-bush). 4. Porous, opens by little holes or chinks at the apex (Azalea, Pyrola, Rhododendron).

Pollen consists of very small, yellow dust-like particles produced within the loculi of the anthers. The stamens exist to produce this, and when, during blossoming, it is shed, their work is done; consequently they wither away.

EXTERNAL APPEARANCE.—Under a microscope (300 power) it appears as grains of various forms—usually round or oval, sometimes triangular or polyhedral, but always alike in the same species, thus often affording a means of recognizing plants. Outside may be (*a*) *Spinose* (Mallow); (*b*) *Oval* but smooth (Lily); (*c*) *Hexagonal* (Chicory); (*d*) *Triangular* (Evening Primrose); (*e*) *Banded* (Pine); (*f*) *Cubic* (Basella).

INTERNAL APPEARANCE.—It has two coats; the outer, called the *extine*, is thick, peculiarly marked, but weak and brittle; the inner, called the *intine*, is thin, smooth, delicate and extensible. This encloses a semi-fluid called *fovilla*, which is the essential part of the pollen-cell, and consists of suspended molecules of inconceivable minuteness, possessing a tremulous motion. These are starch granules, varying in diameter from $\frac{1}{30000}$ to $\frac{1}{4000}$ of an inch, mixed in with what appear to be oil globules.

Some of these are *spherical*—others *oblong* and and others somewhat *cylindrical* with tapering extremities. As the pollen matures this fluid usually dries up, but the protoplasm does not lose its vitality. When the pollen grain is wetted it swells and bursts, discharging thus its contents. When weak syrup is used instead of water, the inner coat slowly breaks through the outer and elongates itself as though placed on the stigma. In Milkweed and most Orchidaceæ the pollen grains do not separate as into a dust or powder, but they cohere into masses called POLLINIA.

The number of these grains in all plants is very great; specially is this true wherever pollen is dependent upon the wind for its dissemination. Here the grains are usually dry, powdery and buoyant from their irregular shape; but where insects do this work, the pollen grains are usually sticky and the smallest in size.

It is said that a single plant of the Chinese Wisteria will produce, during its flowering season, 27,000,000 pollen grains, while a common Pine tree produces a vastly greater number than this.

EXERCISES IN ANALYSIS.

The student may be at a loss this early in the work to recognize, individually, without assistance, when he comes across the particular characteristic flower mentioned in the text illustrative of the various named floral peculiarities. It is true that quite a number are given,

but in reality a very few will suffice for the general intelligence, and those living in rural districts can readily obtain these by self-collections and through the kindness of botanically inclined friends, who will be found almost everywhere, while those living in cities can gather the flora of the surrounding country and also have free access to the public and private greenhouses and botanic gardens, through the universal courtesies of the keeping florists, who are always too glad to give, with their proper title, many of the blooms pertinent to our subjects. For this chapter, collect and pull carefully apart (dissect) as many of the following flowers as possible, always applying to the respective parts the scientific nomenclature herein outlined and described: 1. Cypripedium, Dandelion, Lily, Lobelia, Lupini, Pæony, Petunia, Wall-flower. In these note particularly (*a*) *Calyx*, (*b*) *Corolla*, (*c*) *Stamen*, (*d*) *Pistils*, (*e*) *Torus*, (*f*) *hypogynous*, (*g*) *perigynous* and (*h*) *epigynous* conditions. 2. Abutilon, Apple, Barberry, Cherry, Cucumber, Hibiscus, Lily, Mallow, Pine, Primrose, Pumpkin. In these note (*a*) *parts present;* (*b*) *relation of stamens;* (*c*) *anthers, extrorse, introrse, number of cells, connective, innate, adnate, versatile;* (*d*) *character and shape of filaments;* (*e*) *markings and shape of pollen grains.*

In order to satisfactorily do this and thus make analysis interesting, one must necessarily be equipped with a small, simple microscope (hand or pocket lens), the cost of which need not exceed seventy-five cents. The ordinary "linen tester," which magnifies about twenty diameters, I have always found to give perfect satisfaction and to be admirably adapted for such primitive work.

Recapitulation.

FLOWER

- **Calyx** (Sepals), **Corolla** (Petals) = ENVELOPING ORGANS (Perianth)
- **Stamens or Andrœcium** (Filament) (Anther) (Pollen), **Pistil or Gymnæcium** (Ovary) (Style) (Stigma) = ESSENTIAL ORGANS
- **Torus or Receptacle**, **Peduncle** (Pedicel) = SUPPORTING ORGANS

Enveloping and Essential Organs =

- Complete
- Perfect
- REGULAR = Rotate, Salver, Campanulate, Funnel, Tubular.
- Symmetrical
- Alternation
- Distinct
- Incomplete
- Imperfect
- IRREGULAR = Papilionaceous, Labiate, Ligulate
- Unsymmetrical
- Cohesion
- Adhesion
- Gamopetalous
- Polypetalous

Hypogynous, Perigynous, Epigynous.

STAMENS = Insertion, Relation, Number

ANTHERS = Adnate, Innate, Versatile, Introrse, Extrorse, Connective; **DEHISCENCE** = 1. Longitudinal, 2. Transverse, 3. Valvular, 4. Porous.

POLLEN = External appearance. Internal appearance.

CHAPTER VI.

THE PISTILS IN PARTICULAR.

FIRST: PHANEROGAMIC PLANTS.

I. **Angiospermous Pistils** having the ovules clothed or enclosed in a sac. This is the ordinary and by far the most common kind.

The Gynæcium is the technical and convenient name for the pistils as a whole—Pistillate system—and it occupies the central portion of the flower (see *d*, Fig. 2); these are the female organs of reproduction and when complete consist of three parts, (*a*) *Style*, (*b*) *Stigma*, (*c*) *Ovary* (see Fig. 9).

1. THE STYLE is the slender column connecting the ovary and stigma (see intermediate slender portion, Fig. 9); it is not at all neccessary—no more so than the filament in the stamen. Here likewise when absent the stigma is said to be *sessile* as it rests directly on the ovary (Anemone, Barberry, Poppy).

The style may have a narrow canal through its centre, or its whole make-up may be of thin-walled, cellular tissue, the cells of which assist in secreting the *stigmatic fluid.*

Insertion or Origin.—It may arise from the summit of the ovary=*apical* (Primrose), or from the side = *lateral* (Strawberry), or from the base=*basa-*

lar (Alchemilla). If it falls off when fruit is ripening = *deciduous* (Scirpus), or if it adheres to the ripened fruit = *persistent* (Digitalis, Scrophularia, Snapdragon).

Shape. — It may be thread-like = *filiform* (Fuchsia); club-shaped = *clavate* (Orange); awl-shaped = *subulate* (Cyclamen); petal-like = *petaloideous* (Iris), or it may be *simple* or *branching*. Its surface may be smooth or it may be covered with various kinds of hairs, which become of service in brushing out pollen from the anthers, or in preventing pollen from falling on its own stigma.

2. THE STIGMA is the apical portion and is absolutely essential, as it receives the pollen which fertilizes the ovules, thus converting them into seeds (see extreme tip, Fig. 9). It may possess a very thin epidermis, though generally without such a layer, and is composed mostly of *conducting tissue.* It secretes during fertilization *stigmatic fluid,* a viscid saccharine fluid material which causes the growth and protrusion of pollen tubes, and serves in preventing the escape of pollen, when once brought in its immediate contact; and the stigma is usually more or less roughened for a like purpose.

Insertion or Origin.—It may arise from the summit of the style = *apical* or *terminal*, or from the side = *lateral* or *confluent*, or from the top of the ovary = *ovarian*.

Shape.—The stigma has many forms, may be *simple* or *lobed*, disc-like = *discoid*, hooded = *cuculate*,

fan-shaped = *flabellate*, *filiform*, *globular*, *hemispherical*, *petaloid*, feathery = *plumous*, beaked = *rostrate*, or star-shaped = *stellate*. The divisions of the stigma generally indicate the number of carpels united in forming the ovary (Campanula = five-cleft, Acanthaceæ, Bignoniaceæ, Scrophulariaceæ = two-cleft, Compositæ, Graminaceæ = three-cleft).

3. THE OVARY is the basalar portion and is absolutely essential, as it contains the ovules or rudimentary seeds (see lower portion of Fig 9). When ovary free from calyx = *superior*, when partially adhering = *half superior* or *half inferior*, when completely enveloped in adnate calyx tube = *inferior*.

Position.—If there be only one pistil it is in the immediate centre of the flower (Cherry, Pea); if two, they face each other (see *d*, Fig. 2); if several, they are in a central circle alternating with the stamens (Poppy); if numerous, they are in several circles on an elongated receptacle (Tulip tree).

Number.—These take their numerical names by prefixing the Greek numerals to the adjective form *gynous*, which is analogous to the stamen system.

Monogynous = having one pistil, either simple or compound.

Digynous = having two pistils.

Trigynous = having three pistils.

Tetragynous = four pistils.

Pentagynous = with five pistils.

Hexagynous = with six pistils.

Polygynous = many pistils.

FIG. 9.

Composition. — The pistil, while bearing no resemblance often to the ordinary leaf, on the other hand it does sometimes show very clearly such a relationship. If we take a Cherry leaf (see Fig. 9), now roll one edge over to the other involutely and fasten side to side, leaving an eighth or a quarter of an inch of each margin on the inside, we will have a pouch near the shape of the typical pistil. The lower dilated portion will correspond to the *ovary*, the apical portion to the *stigma*, the narrow portion between the two to the *style*, and the infolded margins in the cavity to the ovule-bearing portion or *placenta* (see ripened follicle of Caltha, Columbine, showing such an analogy).

If a pea pod be laid carefully open we will find that the peas are attached to the placenta in two rows, each row corresponding to a margin of the infolded leaf, and it will be observed that the pod opens down a line between these two edges. This line is called the *ventral suture*. The pod also will open or dehisce along a line just opposite this, corresponding to the midrib of the leaf, this may also bear ovules and is known as the *dorsal suture*.

A leaf thus transformed into an ovule-bearing organ is called a *carpel* (Gr. καρπός, fruit, in reference to the fruit being formed from the pistil), and according to whether a pistil is composed of *one* or *more* than one *carpel*, is it *simple* or *compound*.

The Simple Pistil consists of a single leaf (Apocarpous), has only one placenta, a single stigma and, if not sessile, a single style (Aconite, Blackberry, Buttercup, Golden Seal, Leguminosæ). (See Fig. 9.) Flowers may have several of such *simple pistils*, arranged *opposite*, *alternate* or in *whorls*, (Stonecrop, etc.), when it is more correctly termed a *compound apocarpous pistil.*

From this normal condition we may have some variations: the stigma may be two-lobed, two-ridged, because it consists of two leaf margins, or it may become *two-locellate* by the growing inward of one of the *sutures*, but still it is only a *simple pistil.*

The Compound Pistil consists of a combination of two, three or more single leaves (Syncarpous) in a circle, united into one body, at least by their ovaries (Flax, Hypericum, Primrose, Saxifrage, Stonecrop, Tobacco). (See Fig. 10.) This compound condition can be invariably recognized by the external lobing of either the stigma or ovary, or by the internal structure of the ovary alone. Thus a *three-carpel ovary* may have three internal divisions or cells, or it may have three double rows of ovules on its walls.

Placentation.—The simplest case of compound pistil is:

1. *Axile* or *Central Placenta, with two or more cells.* Here we have just as many cells as there are carpels united to compose the pistil. This is precisely the same condition as though the circle was composed of just as many single pistils pressed and cohering together in the centre of the flower

(Campanula, Lily, Pæony, Stonecrop). Naturally all the placenta are *axillary* and the ovary has as many *Dissepiments* as their are carpels. Such pistils ripening into pods often separate along these lines into their elementary carpels.

2. *Free Central Placenta, with one cell.* Here the partitions are suppressed or have early vanished (Chickweed, Pink, Purslane). Traces of such septa are often detected in Pinks, etc.

The ovules are borne apparently on a column which rises free from the bottom of the ovary (Primrose, Soapwort). According to the number of cells, ovaries are known as *unilocular, bilocular, trilocular, multilocular.*

FIG. 10.

3. *Parietal Placenta, with one cell.* Here number of double rows of ovules corresponds with the number of carpels composing the pistil; these leaves coalesce by their adjacent edges as in gamosepalous and gamopetalous perianth. Each placenta consists of the contiguous margins of two pistil carpels grown together (Caltha, Cactus, Mignonette, Pea, Poppy), Fig. 10 is a cross section of Helianthemum having three parietal placentæ-bearing ovules.

II. Gymnospermous Pistils, having ovules naked.

This Gynæcium is the simplest kind but very peculiar. They are open leaves or scales, each bearing two or more ovules on the inner face, next the base (Arbor Vitæ, Cedar, Larch, Pine). During blossoming these scales diverge, and the pollen, so abundant, is shed, falling directly upon

the exposed ovules; after this, the scales close together again till seeds are ripe, when they open and shed them. The pollen acts directly on the ovules, there being no stigma. In the Gingko, Torreya, and Yew, we have only a naked ovule without any visible carpel. In the Cycas the naked ovules are on the margins of the open leaf.

SECOND: CRYPTOGAMIC PLANTS.

These have organs called *pistillidia* which perform the functions that pistils do in phanerogams. They are hollow flask-shaped-like ovaries called *sporangia* (σπορὰ, a spore or seed+ἄγγος, a vessel) or *thecas* (θήκη, a sack) and contain small bodies named *spores*, equivalent to ovules, which are capable of germination although devoid of cotyledons. The *sporangia* or *spore cases* may occur immersed in the substance of the plant=Riccia glauca, or supported on stalks or setæ (L. *seta*, a bristle)= Mosses, or as distinct expansions, flask-shaped, having the spores in the enlarged lower part which is surrounded by a cellular coat resembling a calyx. From this ovary-like body prolongations extend representing *styles*, these are terminated by a cellular enlargement analogous to the *stigma*. This styloid arrangement withers and disappears when the spores mature. Sometimes these sporangia are *elongated club-shaped cells* or *ascus* containing internally nuclei or cells which form the spores=Lichens. Sometimes these are single or united in sets of two, four or multiples. They may be surrounded by annular rings or elastic bands which cause dehiscence = Ferns.

CHAPTER VII.

THE OVULES IN PARTICULAR.

The Ovules are the small bodies in the ovary, which, after fertilization, become the seeds; are sometimes *few*, again *numerous*, and may be an outgrowth of the leaf's marginal teeth or of plant-hairs modified, they are borne on specific surfaces called the *placenta* and as to position and direction in the ovary may be:

(*a*) *Horizontal*=laying level—neither inclined upward nor downward (Podophyllum).

(*b*) *Ascending*=rising obliquely from the side (Buttercup, Purslane).

(*c*) *Erect* = rising perpendicularly from basal centre (Buckwheat).

(*d*) *Pendulous*=hanging from side near the top (Flax).

(*e*) *Suspended*=hanging perpendicularly from the top (Anemone).

All these characteristics apply equally to the seeds.

The Ovule Complete consists of the following parts:

1. KERNEL=the body of the ovule. In some plants only this part exists (Mistletoe).

2. TEGUMENTS = generally two, an outer=*Pri-*

mine, an inner=*Secundine*, only one coat present in gymnospermous plants.

3. FUNICULUS=the stalk or ovule stem, this may be absent when ovule is said to be *sessile*.

4. FORAMEN=an apical opening for the reception of pollen tube. In seed=Microphyl.

5. CHALAZA=point at the base where kernel and two teguments blend together.

6. HILUM=the point of attachment of the funiculus to the rest of the ovule.

7. RAPHE=that part of a long funiculus growing fast to the ovule.

THE SHAPE of these ovules vary:

1. *Orthotropous*, ôr-thŏt′rō-pŭs (Greek ὀρθός, straight, normal + τρέπειν, to turn) = hilum and foramen at opposite ends.

2. *Campylotropous*, kăm′pĭ-lŏt′rō-pŭs (Gr. καμπύλος, curved + τροπή, a turning) = body so curved as to resemble a kidney, having hilum and foramen approximated.

3. *Amphitropous*, ăm-fĭt′rō-pŭs (Gr. ἀμφί, around + τρέπειν, to turn)=half *inverted* (*anatropous*); the funiculus is near the middle of the straight body, pointing at right angles to it; body is straight, chalaza at one end and the foramen at the other.

4. *Anatropous*, ȧ-năt′rō-pŭs (Gr. ἀνά, up + τρέπειν, to turn) = *inverted;* the chalaza at one end and hilum and foramen adjacent to each other at the other end; opposed to *orthotropous*.

In the last two cases funiculus is adherent to ovary, and these are the most common varieties.

THE TORUS OR RECEPTACLE IN PARTICULAR.

This is commonly a flat or convex disk whose centre corresponds to the apex of the axis, sometimes called *thalamus* or *thallus.* Apart from this it has some interesting modifications:

A stipe = a stalk, and this receives different names dependent upon the connection. If it is the petiole of a carpel = *Thecaphore*, if it is under a compound pistil = *Gynophore* (Cruciferæ, Stanleya,), if one under the stamens also = *Gonophore*, if prolonged up between the carpels = *Carpophore*, (Geranium, Umbelliferæ).

Flowers with numerous simple pistils have large receptacles, *broad* = Raspberry, *elongated* = Blackberry, Magnolia.

The receptacle is the *edible* portion of the Strawberry and the seeds are each a *pistil.* In Rose, the receptacle is *concave.* In Nelumbium the enlarged receptacle is *top-shaped* and bears the small pistils immersed in separate cavities of its flat upper surface.

A disk = an enlarged low receptacle or an outgrowth from it, this when under the ovary = *hypogynous* (Orange, Rue), *perigynous* when adnate to calyx tube (Buckthorn, Cherry, Rose), or to both calyx tube and ovary (Hawthorn), and *epigynous* when on the summit of the ovary (Umbelliferæ.)

INFLORESCENCE OR ANTHOTAXIS.

Inflorescence is the arrangement and position of the flowers or blooms upon the plant's stem and its various branches. Flower buds and leaf buds have their origin from identical places, that is, they both are either *terminal* or *axillary.* Consequently flowers correspond to branches and their parts to leaves.

Inasmuch, then, as flower buds are always either *terminal* or *axillary,* it would naturally follow that we should have but these two kinds of inflorescence, and primarily this is true. At the same time we occasionally see plants that are not exclusively the one (terminal) or the other (axillary), but have both kinds occurring here and there over its branches, such are said to have *mixed inflorescence.* As to distinctive types, however, we only have two, viz. :

1. *Indeterminate—Axillary or Centripital Inflorescence.*

2. *Determinate—Cymose or Centrifugal Inflorescence.*

The *first* or *indeterminate,* so named because its terminal bud never converts itself into a flower bud but keeps on lengthening its stem continuously, has the following forms: *Raceme, Corymb, Umbel, Spike, Catkin, Head, Strobile, Spadex, Panicle.*

The leaves of all these flower clusters are called *Bracts,* if any on the pedicel flowers they are called *Bractlets.*

The Raceme (L. *rhachis,* back-bone) is a cluster in which the flowers, each on its own pedicel, occur in succession along the sides of the axis of

inefloresence, blossoming from the base towards the apex (Barberry, Choke-cherry, Convolvulus, Currant). (See Fig. 11. Here (p) = general peduncle, (p') = pedicels, (b) = bracts and (b') = bractlets.)

The Corymb (L. *Corymbus*, flower cluster) is like a raceme, only the pedicels are so lengthened as to have a broad convex or level top (Cherry, Prunus).

The Umbel (L. *umbella*, a little shadow) resembles the raceme, only the pedicels are all about the same length, and these radiate from the top of the peduncle, like the umbrella-ribs or rays, whence the name. The bracts are here in a circle, and form what is called an *Involucre* (L. *involucrum*, a covering). (Conium, Coriander, Onion, etc.)

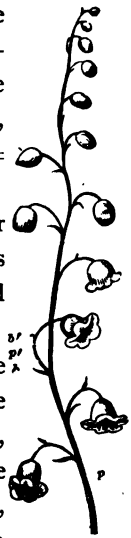


FIG. 11.

The Spike (L. *spica*, a plant) is a raceme sessiled (Plantain, Rib-grass, Vervain). (See Fig. 12.)

The Catkin or Ament (Cat + kin, resembles catstail—*amentum*, thong), is a spike with scaly instead of herbaceous bracts (Alder, Birch, Hickory, Oak, Poplar, Willow).

The Head or Capitulum (L. *caput*, head) is a corymb or an umble sessiled; here the rachis is very short (Button Bush, Clover, Dandelion, Marigold, Mimosa).

FIG. 12.

The Strobile (L. *strobilus*, cone) is a compact

cluster, having large scales which conceal the flowers (Hops).

The Spadix (L. *spadix*, a broken palm branch with its fruit) is a fleshy spike or head of flowers usually inclosed in a leaf called the *spathe* (Calamus, Calla, Indian Turnip).

The Panicle (L. *panicula*, a tuft on plants) is a compound raceme with open and irregular branching (Grasses, Oats, Yucca). Several others of these forms just described may be more or less compounded; thus, compound umbels (Caraway, Parsnip, Umbelliferæ). The secondary umbels here are called *umbellets*, and the involucre to these is called *involucel.* The *compound corymb* (Mountain Ash), *compound raceme* (Smilacina racemosa), *compound spikes* (Oats), and *compound panicles* all are met with occasionally.

The *second* or *determinate* inflorescence is so named because the first flower that opens is the terminal one of the rachis, and the others appear in succession from the apex toward the base; the principal form of this type are *Solitary*, *Cyme*, *Fascicle*, *Glomerule*, *Cymule*, *Scorpioid* or *Helicoid Cyme.*

The Solitary is where there is a single flower at the end of the stem. This stops the stem's growth in length or height so that all further increase must take place from axillary buds developing into branches (Wood Anemone).

The Cyme (Gr. κῦμα, swollen) is a flat-topped cluster, like a corymb from terminal buds, the simplest kind being of three flowers. In this the flowering branches must bear only bracts in place

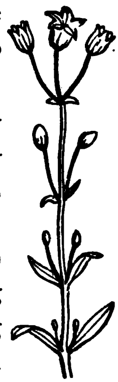


FIG. 13.

of ordinary leaves (Cerastium). (See Fig. 13), here axis lengthens so as to resemble raceme.

The Fascicle, (L. *fasciculus*, bundle) is where a cyme has shortened pedicels and is compactly arranged (Lychnis, Sweet William).

The Glomerule (L. *glomus*, ball) is a cyme still more compacted, having sessile flowers or short rachis, imitating a head, but has inflorescence centrifugal (Buttercup, Cinquefoil, Dogwood, Rose).

The Cymule (L. *dim.*) is either a reduced cyme of few flowers, or a branch of a compound cyme, *i. e.* a partial cyme.

The Scorpioid or **Helicoid Cyme** (Gr. σκορπίος, a scorpion + εἶδος, form, resembling, ἕλιξ—ικος, spiral + εἶδος, shape, resembling) is one imitating a raceme very much, having flowers pediceled along a lengthened axis, but either all of those on one side (helicoid) or every alternate one (scorpioid) fail to appear. These are *incomplete cymes* (Forget-me-not, Heliotrope, Sundew).

Mixed Inflorescence is where we have the indeterminate, and determinate plans combined. The *mixed panicle* has the primary ramifications *indeterminate* and the secondary *determinate*. A contracted or elongated infloresence of this sort is called a *Thyrsus*, (Horsechestnut, Lilac). In Compositæ, the heads are *determinate*, but the branches or peduncles bearing the heads are usually *indeterminate*.

Recapitulation.

PISTIL =
- ANGIOSPERMOUS =
  - Style = Origin, Shape
  - Stigma = Origin, Shape
  - Ovary = Ovules = Kernel, Teguments, Funiculus, Foramen, Chalaza, Hilum, Raphe
    - = Position, Number, Composition
      - Composition = Simple, Compound
        - Compound = Axile, Free Central, Parietal.
- GYMNOSPERMOUS.

TORUS, STIPE = Thecaphore, Gynophore, Gonophore, Carpophore, Disk

INFLORESCENCE =
- Indeterminate = Raceme, Corymb, Umbel, Spike, Catkin, Head, Strobile, Spadix, Panicle.
- Determinate = Solitary, Cyme, Fascicle, Glomerule, Cymule, Scorpioid.
- Mixed.

CHAPTER VIII.

PREFOLIATION AND PREFLORATION.

First Prefoliation prē-fō′lĭ-ā′shŭn. (L. *præ.*, before + *folium*, leaf.) This is the condition in which rudimentary leaves occur in the bud, and can be considered from two standpoints, viz.:

1. *Independently*, as to how each individual leaf itself is folded or curved irrespective of all others.

2. *Dependently*, as to how they are arranged in reference to each other.

INDEPENDENTLY. Of this we have two divisions. (*a*) *Bent* or *Folded*, (*b*) *Rolled*.

Belonging to (*a*) we have three varieties:

1. *Inflexed*, when apex is bent inward toward the base (Tulip-tree).

2. *Conduplicate*. When the right half is folded inward upon the left, bringing margin to margin (Cherry, Magnolia, Oak).

3. *Plicate*. When folded back and forth like the plaits of a fan (Birch, Currant, Sycamore).

Belonging to (*b*) we have four varieties:

1. *Circinate*. When rolled inward from the apex toward the base (Ferns, Sundew).

2. *Convolute.* When rolled inward from one margin to the other (Apricot, Plum, Wild Cherry).

3. *Involute.* When rolled inward from both edges to the midrib (Violet, Water Lily).

4. *Revolute.* When rolled outward from both edges to the midrib (Azalea, Rosemary, Yellow Dock).

DEPENDENTLY. Of this we have two divisions: (*a*) *Flat* or *Slightly Convex*, (*b*) *Bent* or *Rolled*.

Belonging to (*a*) we have three varieties:

1. *Valvate.* Where the margins just touch, all at the same level.

2. *Imbricate.* Where the outer successively overlap the inner; here the leaves are at different levels (Lilac, Sycamore).

3. *Spiral.* Where the margin of one leaf overlaps that of another, while it, in its turn is overlapped by a third.

Belonging to (*b*) we have four varities:

1. *Induplicate.* Where the margins of involute leaves just touch.

2. *Equitant.* Where outside conduplicate leaves set astride of those next within (Iris, Privet).

3. *Obvolute.* (Half Equitant). Where half of one conduplicate leaf is in the folds of another similarly folded leaf (Sage).

4. *Supervolute.* Where a convolute leaf encloses another similarly folded (Apricot). *This prefoliation is also known as Vernation* (L. *ver*, spring = the spring state).

Second Prefloration prē'flōr-ā'shŭn. (L. *præ.*, before + *flos*, *floris*, flower.) This is the condition in which the altered leaves (sepals and petals) occur in the fully developed flower. It is nearly the same as in *prefoliation* and on that account many of the names used are common to both. Here we have also to consider from two standpoints, viz.:

1. *Independently.* 2. *Dependently.* The former is subdivided into (*a*) *Bent* or *Folded*, (*b*) *Rolled*, (*c*) *Crumpled* or *Corrugated*, not found in prefoliation (Helianthemum, Papaver). The latter is subdivided into (*a*) *Circular*, (*b*) *Imbricated* or *Spiral.*

1. INDEPENDENTLY. What was said under this head in *prefoliation* is sufficiently correct as to have application here without further comment.

2. DEPENDENTLY (*a*) *Circular.* Here all the components are in circular whorls, in the same plane and is thus subdivided: 1. *Valvate*, (Lime *calyx*). 2. *Induplicate* (Clematis). 3. *Reduplicate* (Hollyhock). 4. *Contorted* or *Twisted* (Flax). (*b*) *Imbricated* or *Spiral.* Here all the components are in spiral whorls at different levels, thus overlap one another, and is subdivided as follows:

1. *Imbricate* = overlapping like tiles on the roof of a house (Camellia Japonica *calyx*).

2. *Convolute.* Where parts completely envelope each other (Camellia Japonica *corolla*).

3. *Quincuncial*, kwĭn-kŭn'shal (L. *quinque*, five), here have five parts, *one* and *two* are external, *four* and *five* internal, *three* partly both (Rose *corolla*).

4. *Cochlear*, kŏk'lē-ĕr (Gr. κόχλος, spiral shell fish), here *one* of the two which in the above is external becomes internal (Snapdragon).

5. *Vexillary*, is where the vexillum folds over the others which are arranged face to face (Leguminosæ, Pea).

We frequently have the calyx *valvate* and the corolla *induplicate* or *twisted* (Malvaceæ), or again the calyx may be *quincuncial* or *imbricate* and the carolla *twisted*.

The kinds of *prefloration* are constant in the same species, and often throughout genera and natural orders, hence are important in Systematic Botany as well as Structural Botany, as they assist in revealing the relative succession and position of the floral parts on the axis. This *prefloration* is also known as Æstivation, ĕs-tĭ-vā'shŭn, (L. *æstas.*, summer = the summer state).

The flower has specific names to characterize its position on the axis of inflorescence, thus:

1. *Posterior*, *Superior*, *Upper*, has reference to that portion of the bloom turned toward the axis. In the case of the Labiate corolla (fives) = that portion composed of two petals (Lamium). In the case of Leguminosæ *calyx*, we have *two superior*, *two lateral*, *one inferior*, while in the *corolla*, *one superior*, *two inferior*, *two lateral*. In the Rosaceæ the order of caylx and corolla is just reversed.

2. *Anterior*, *Inferior*, *Lower*, is that portion facing the bracts. When in fours, *one is superior*, *one inferior*, *two lateral* (Wallflower).

THE COLOR OF FLOWERS.

It is by some thought that there exists a coloring matter in all plants called *chromogen* which consists of two components, one being red with acids, the other yellow with alkalies. Thus even *leaves*, whose color is due to chlorophyl in sub-epidermal cells + sunlight—remaining yellow in the dark—assume various tints; for example, the Agave = from pale to deep green, the Beech and Beet = uniform red or copper color, the Begonia, Cyclamen, Saxifraga and Tradescantia = green above, red or brown below, the Aucuba Japonica, Carduus marianus and Calathea zebrina = yellow spotted, Arums = red spotted. *The sap*, though transparent in the plant cells, on exposure may become highly colored: Œnanthe crocata = yellow, Chelidonium = orange, Madder = yellow to red, Boletuses = blue. *The bark*, from green = brownish due to deposit of brown matter. *The wood*, from green tissue = colored duramen, Ebony, Guaiac, Walnut. This is accomplished, not alone by oxidation, but through internal chemical action. *The flowers*—all the colors here as red, blue, yellow, etc., depend on *coloring matter* dissolved in the sap of the superficial cells and on *chromo plastids*. The changes of color which take place in many corollas is due to the oxidation of these

bodies; thus, the Boraginaceæ, in expanding, pass from *pink* to *blue* and Convolvulus = from *pink* to *purple*. By cultivation the Dahlia and Tulip, though yellow, may become various shades of red, orange, white, but no blue. Pelargoniums and Hydrangea may become blue, purple, red, white, etc., but never yellow. From such facts De Candolle divided flowers into two series: 1. The *Xanthic* (ξανθός, yellow). 2. The *Cyanic* (κυανός, blue); and they have these respective colors for their base, either of which can be made red or white, but will not assume the basic color of the other. To the *Xanthic series* we have *yellowish green*, *yellow*, *orange-yellow*, *orange*, *orange-red*, *red* (Adonis Aloe, Cactus, Cytisus, Dahlia, Oxalis, Œnothera, Potentilla, Ranunculus, Rose, Tulip, Verbascum). To the *Cyanic series* we have *greenish blue*, *blue*, *violet-blue*, *violet*, *violet-red*, *red* (Anagallis, Campanula, Epilobium, Hyacinth, Geranium, Phlox). Flowers often change color according to the time of day; thus, Phlox in morning = *light blue*, in afternoon = *bright pink;* Œnothera tetraflora = *white*, then *red;* Hibiscus variabilis = *white* in morning, *pink* at noon, *bright red* at sunset. The bracts of Hakea Victoria during first year = *yellowish white* in the centre, second year this portion = *golden yellow*, third year = *orange*, fourth year = *blood red*. The soil effects the color of flowers very materially; thus, Hydrangea hortensis from *pink* to *blue* when grown on loam and peat earth, while alum added to the soil produces

similar result. The relative proportion of flowers to colors in say 4000 species have been determined thus: *White* = 1193, *yellow* = 951, *red* = 923, *blue* = 594, *violet* = 307, *green* = 153, *orange* = 50, *brown* = 18, *nearly black* = 8. Of 120 species examined in the following Natural Orders, the colors were as follows:

	Red.	Violet.	Blue.	Green.	Yellow.	Orange.	White.
Nymphæaceæ	11	—	14	—	28	—	46
Rosaceæ	32	1	—	—	52	—	40
Primulaceæ	41	7	6	2	15	10	27
Boraginaceæ	10	9	28	3	13	1	35
Convolvulaceæ	39	10	12	—	7	2	27
Ranunculaceæ	16	4	15	2	42	1	19
Papaveraceæ	38	9	—	—	36	7	7
Campanulaceæ	5	21	58	—	3	1	10

Flowers should always be arranged so that the complementary colors are together; thus, the complementary color of *red, i. e.*, that which produces white light is *green*, that of *orange* = *blue*, that of *yellow* = *violet*. Consequently, *blue* and *orange*-colored flowers, *yellow* and *violet* may be placed together.

Red and *rose*-colored flowers harmonize with their *green* leaves, and when harmony is broken the interposition of *black* or *white* affords a good correction.

THE ODORS OF FLOWERS.

These depend on various secreted volatile oils, resins, etc., which sometimes cannot be detected even by chemical means. The causes which

render some flowers with and others without odor are not known. Most flowers loose their odor upon drying, while some leaves (Woodruff, etc.) acquire scent by desiccation. Some of the woods (Teneriffe Rosewood, etc.) acquire it when warmed by friction.

Mild rain, or dew with intervening sunshine, act best towards eliciting vegetable perfumes. Sunlight modifies both odor and color. The relation numerically between color and odor is quite interesting; thus, in examining a number of monocatyledonous and dicotyledonous plants, the following results have been obtained:

Color.	No. of species.	Odoriferous.	Agreeable.	Disagreeable.
White	1193	187	175	12
Yellow	951	75	61	14
Red	923	85	76	9
Blue	594	31	23	7
Violet	307	23	17	6
Green	153	12	10	2
Orange	50	3	1	2
Brown	18	1	0	1

In examining 100 species of each of the subjoined Natural Orders, the following results were obtained;

	Odorous.	Non-odorous.
Nymphæceæ	22	78
Rosaceæ	13	87
Primulaceæ	12	88
Boraginaceæ	6	94
Convolvulaceæ	4	96
Ranunculaceæ	4	96
Papaveraceæ	2	98
Campanulaceæ	1	99

EXERCISE IN ANALYSIS.

To study at good advantage the subjects just treated, a number of blooms, representing various genera, should be collected and the various parts carefully compared, each with its kinds, by making longitudinal and transverse sections with a very sharp knife.

1. *For Pistils* collect, Buttercup, Hollyhock, Indian Corn, Lily, Pea, Poppy, Primrose, Pumpkin, Rose, Rubus, Saxifrage, Stramonium, and note (*a*) *the parts present* (*b*) *if apocarpous or syncarpous, simple or compound, and to what degree;* (*c*) *whether placentæ* PARIETAL, AXILE or FREE CENTRAL; (*d*) *the amount of attachment the ovary has to adjacent parts, the arrangements and shape of ovules* (*e*) *the position and shape of the style and stigma.*

2. *For Inflorescence* collect, Burdoch, Carrot, Currant, Dogwood, Frost Grape, Hare Bell, Hydrangia, Milkweed, Mustard, Oats, Potato, Sycamore, Wheat, Willow, and note which are (*a*) *Indeterminate*, (*b*) *Determinate* (*c*) *Mixed.*

3. *For Prefoliation*, collect *the buds or unfolding leaves* and accurately determine the prefoliation or vernation of each, Ash, Custard Apple, Hickory, Geranium, Maple, Oak, Plantain, Polypodium, Sweet Flag, Sycamore.

4. *For Prefloration* collect the *flower buds*, *examine the calyx and corolla, draw diagrams showing the arrangement, and properly apply* the name descriptive of each kind of prefloration of the Apple, Buckthorn, Buttercup, Clover, Geranium, Grape, Mustard, Stramonium.

Recapitulation.

- **PREFOLIATION** =
  - INDEPENDENT =
    - (*a*) BENT OR FOLDED = 1 Inflexed, 2 Conduplicate, 3 Plicate.
    - (*b*) ROLLED = Circinate, Involute, Convolute, Revolute.
  - DEPENDENT =
    - (*a*) FLAT OR CONVEX = Valvate, Imbricate, Spiral.
    - (*b*) BENT OR ROLLED = Induplicate, Equitant, Obvolute, Supervolute.
- **PREFLORATION** =
  - INDEPENDENT =
    - (*a*) BENT
    - (*b*) ROLLED
    - (*c*) CRUMPLED

    Same as in Prefoliation.
  - DEPENDENT =
    - (*a*) CIRCULAR = Valvate, Induplicate, Reduplicate, Contorted.
    - (*b*) IMBRICATE = Imbricate, Convolute, Quincuncial, Cochlear, Vexillary.

COLORS OF FLOWERS =
1. Xanthic (yellow base).
2. Cyanic (blue base).

CHAPTER IX.

POLLINATION AND FERTILIZATION.

While these two terms are not identical in meaning, at the same time they have such a mutual dependence on one another that in treating either separately the other will be more or less involved. Indeed, by some the two words are used synonymously, yet they each have a restricted signification. The one object of these two processes conjointly is to effect the conversion of *rudimentary ovules* into *germinating seeds.* In the former condition they may have outline, shapely appearance, and yet be worthless for propagation; but in the latter condition they are capable of reproducing their parental kind, be that what it may, provided favorable surroundings are afforded.

1. POLLINATION.—This is taken to express, as a whole, the various methods by which the pollen of the stamen is conveyed to the pistil, so as to produce seed setting or *Fertilization.*

For a long time it was supposed that each flower had this power inherently, and thus performed pollination as a regular function. To more recent investigators many observed facts could not be reconciled harmoniously with transmitted hypothesis, consequently thought became so liberal that

scientists only admitted those flowers possessing essential organs, owing to their juxtaposition, to be *self-pollinizing* or *fertilizing*. And when we come to the present stage of knowledge we find that even in hermaphroditic flowers, self-pollination or fertilization is the exception and not the rule. We, therefore, find three classes of flowers dependent upon the method by which they are *pollinized* or *fertilized*.

1. Those particularly adapted to *close* or *self-fertilization*, which have received the name *autogamous*, a-tŏg′ă-mŭs (Gr. αὐτός, self + γάμος, marriage).

2. Those that are solely planned for *cross-fertilization*, and are called *allogamous*, ăl-lŏg′ă-mŭs (Gr. ἄλλος, other + γάμος, marriage).

3. Those that are adapted for either the one or the other, according to circumstances.

CLOSE FERTILIZATION is where the pollen from the stamens of any given plant reaches and acts upon the pistils of the same bloom, cluster or plant.

CROSS FERTILIZATION is where ovules are fertilized by pollen from other individuals of the same species.

HYBRIDIZATION is where ovules are fertilized by pollen from other individuals not the same, but of some closely related species of the same genus.

I. Close or Self-Fertilization.—While this might seem the natural process in hermaphrodite flowers, at the same time their parts are more frequently arranged so, that they will not accept their own pollen until many opportunities for cross-fertilization have been provided and

offered. This is inevitable, however, in *cleistogamous flowers.* (Gr. κλειστός, closed + γάμος, marriage), where the flower buds never open until compelled to do so by the enlargement of the precociously fertilized pistils. Such flowers are mostly concealed under ground; hence, insect visitation being impossible, the pollen falls directly upon the stigma and thus fertilization takes place. The production of this kind of flowers, with their numerous seeds, seems an economic provision of nature, since it requires a less expenditure of force to create these than an equal number of ordinary blooms. All plants bearing these cleistogamous flowers bear also brightly-colored open flowers above ground. These may fail to set seed, but enough crossing from these takes place to keep the stock vigorous, while most of the multiplication arises from tubers, bulblets, etc., resulting from the profusion of closed flower-seeds (Amphicarpæa, Andrewsii, Gentiana, Impatiens, Polygalas, Violets).

It is quite remarkable, and none the less interesting, to note with what degree of apparent intelligence some plants endeavor, *per se,* to effect pollinization and thereby fertilization; thus, in Rue and Parnassia palustris the stamens embrace more closely the pistil just previous to the anthers discharging, thereby insuring the pollen's line of descent, being immediately over the stigma. In Kalmia the anthers are in pouches until the pollen is mature, when, by a combination of expansion of the corolla and elasticity of the filament, they spring toward the pistil with a jerk. In the Cornus,

Nettle and Parietaria officinalis the spiral filament remains folded until the perianth expands, when it bounds upward by elasticity and scatters the pollen. In the Barberry the filament, when touched, approaches the pistil. In Stylidium the anthers and stigmas are seated on a swollen and irritable column. When stimulated, this column passes from one side of the flower to the other, thus rupturing the anther lobes. The Stapelias (carrion flowers) attract blow flies by the fetid odor of their flowers, among whose hairs the flies deposit eggs; these in time hatch and the maggots, in search of food, press the pollen masses down to the stigma and thus cause fertilization. In Oxalis Acetosella the flowers are erect and open in daytime for insect visitation, but by night they have described an arc of 100 degrees, and rest their open mouths hard pressed to the ground, thus preventing the entrance of crepuscular insects; and many other examples might be mentioned.

II. Cross-Fertilization.—This must be the method in diœcious plants, and it is the kind preferred by many monœcious, dichogamous and heterogamous flowers. Such flowers, for the most part, are so constructed as to only allow this kind of fertilization, and often they positively refuse to set seed with their own pollen. It is this crossing, as in the animal economy, that seems to be such a wise provision of nature, as it results in giving us an offspring more prolific, vigorous, of greater size and variety. This cross-fertilization is solely effected by external agencies. Occasionally various

species of birds (mainly insectiverous and humming birds) that visit flowers, are of service, and water currents are useful in some aquatic plants, but the two great agents are the *wind* and *insects.*

ANEMOPHILOUS FLOWERS, ăn′ē-mŏf′ĭ-lŭs (Gr. ἄνεμος, wind + φίλος, lover) are those having their pollen conveyed to the stigma by the wind. These differ vastly in appearance and structure from those pollinated by insects, as here the stigmas are large, exposing a broad surface to the wind. The pollen is dry, powdery and abundant; they have no *showy perianth,* no *nectar* nor *perfume.* These are mostly diœcious or monœcious (Barley, Birches, Coniferæ, Corn, Hop, Nettle, Oak, Oats, Poplars, Rye, Sedges, Walnuts, Wheat, etc.), and yet sometimes hermaphrodite (Grasses, Plantains).

ENTOMOPHILOUS FLOWERS, ĕn′tō-mŏf′ĭ-lŭs (Gr. ἔντομον, insect + φίλος, a lover) are those whose pollen is conveyed to the stigma by insects such as *bumble bees, honey bees, moths, flies,* etc.; all of these are indifferent to as well as frequently ignorant of this great service they are performing, because their visits are for selfish purposes alone—in quest of food from the nectariferous glands. These are so situated that an insect seeking them will be obliged to disturb the pollen or pollinia as they pass in and out of the corolla; they thus get besprinkled with it, and so covered, encounter the stigmas from flower to flower which they subsequently visit.

The kind of flowers so pollinized are mostly *irregular,* or with *showy perianths* or *bracts,* or

those that are *highly perfumed*, or those that are *nectar secreting* (Cruciferæ, Labiatæ, Leguminosæ, Linum, Lobelia, Orchidaceæ, Primula, Scrophulariaceæ, etc.). The *bright colors* and *emitted odors*, whether agreeable or disagreeable (Rafflesia, Stapelias, etc.) attract the insects' attention, while the *nectar*, if any present, compensates their labor, and the flower's *irregularities* are but adaptations for accomplishing easily cross fertilization during their occasional visits. It is seldom that the same flower possesses *lively colors* and *striking perfume;* more generally those having high colors having little odor, while those with much odor are dull colored and without much show.

Most of the *red* and *blue* flowers are visited by diurnal insects in daytime, while the *yellow* and *white* seem to possess most attraction for moths and those insects which fly at dusk or twilight, because these colors, of all others, are most visible by dim light. At the same time it must be remembered that many *white* flowers are also visited during the bright daylight. The various colored stripes on corollas seem to have even a useful purpose, inasmuch as they serve to point to and guide the insects to the nectaries. While some flowers may give out a *delightful perfume*, others have *disagreeable odors*, and each kind equally has its worshiping insects. Thus the giant flower Rafflesia, having a putrefying odor and a beefy appearance, attracts swarms of carrion flies, which in turn, fancying it animal matter, deposit their ovas upon it, thus dooming their maggot offspring to starva-

tion; but, during all this time, however, pollen is often brought by these flies from one flower to another, and thus is cross-fertilization accomplished. Some flowers are open during the day, but close at night, and *vice versa*; others have positive form, color, markings, odor, nectaries, etc.; others have negative form, disagreeable hairs, unpleasant odors, distasteful secretions; others dispense their perfume during the day and are odorless at night, thereby preventing a waste of nectar and pollen through the agency of what are to them useless insects, while others during the mid-day are tightly closed and at night are beautiful in their full development and fragrant with their sweet perfume (Jasmine, Night-blooming Cereus, etc.). All these variations have each a specific purpose, viz., to attract or repel each its own kind of an insect according to preference, and after the *love* or *hatred of the heart.* Thus in all nature everything seems to have an allotted part to play, and it seems an all-wise provision that even here among flowers and insects they each have their counterpart and a cord of common interest, but with a natural selection as it were; one kind of an insect seeking and best adapted, anatomically as well as otherwise, for certain kinds of flowers, and these in turn, with equal precision, influencing the habits of these insects by which they on the one hand can be benefited or, on the other hand, injured. While the Iris, Kalmia, Milkweeds, Orchids—Leguminous, perfume and nectar-bearing, and the Irregular flowers are thus pollinized, we

have in hermaphroditic flowers two conditions, the *dichogamous* and *heterogonous*, which facilitate cross-fertilization, but absolutely prevent self-fertilization.

I. **Dichogamy**, dī-kŏg′ȧ-mȳ (Gr. δίχα, in two + γάμος, marriage) is where anthers discharge their pollen before or after the stigmas, in the same flower, are ready to receive it. Thus we have two variations:

1. PROTERANDROUS or PROTANDROUS, prō′tēr-ăn′-droŭs (Gr. πρύτερος, earlier + ἀνδρός, stamen), when the anthers are earlier than the stigmas (Campanula, Epilobium, Gentians, Geraniums, Lobelias, Pinks).

2. PROTEROGYNOUS or PROTOGYNOUS, prŏ′tēr-oj′ĭ-nŭs (Gr. πρότερος, earlier + γυνή, pistil), when stigmas are earlier than the anthers and have withered away before pollen could be supplied (Amorphia, Hawthorns, Horsechestnut, Papaws, Pears, Plantains, Scrophularia, etc). In addition to this provision of nature, the Clerodendron, and some species of Epilobium, have essential organs possessing specific movements, so as to doubly insure cross-fertilization.

II. **Heterogony**, hĕt′ĕr-ŏg′ō-nȳ (Gr. ἕτερος, other + γόνος, offspring) is where perfect flowers of two sorts are produced on different individuals of the same species; the one having high anthers and low stigmas, the other low anthers and high stigmas. Thus an insect can carry pollen from high stamen to high stigma, and one that visits low stamens exclusively can cross-fertilize the low stigmas (Houstonia cærulea, Mitchella repens, etc.). These have stigmas of two lengths, hence are called *dimorphous* (Gr. δίμορφος = two forms) (Gelsemium, Mentha), or He-

terogone Dimorphism, but if flowers have stigmas of three lengths = long-styled—mid-styled and short-styled, they are called *trimorphous* (Gr. τρι, three + μορφή, form) or Heterogone Trimorphism (Lythrum, Oxalis, Salicaria).

III. Hibridization, hī'brĭd-ĭ-zā'shŭn.—This results sentirely from cross-pollination, and must not be confounded with the crossing of two varieties of the same species, which simply gives rise to *cross-breeds* or *subhybrids*, while hibridization produces *hybrids* or *mules*. It is extremely rare to have hybrids between allied genera, and when so, they are termed *bigeners*, and thus formed, are neither permanent nor long lived.

Hybrids always possess characteristics of both parents, but generally resemble one more than the other. Hybrids seldom produce fertile seeds for many generations, and further propagation has to be effected by budding, grafting, etc. The pollen of one of the parents will fertilize hybrids, and in such cases the offspring resembles that parent most, and if impregnation be taken from the same side for three or four generations the resultant offspring will revert to the original male or female type. Hybrids rarely occur in wild plants, mainly from *a natural preference* and *elective affinity* for the pollen of its own species and an aversion for other kinds; thus, if you supply a stigma with two kinds at once, its own will be accepted for fecundation and the other becomes inert and worthless. Hybrids can quite readily be formed by gardeners sporting with the pollen of various plants.

CHAPTER X.

POLLINATION AND FERTILIZATION.

2. FERTILIZATION.—This is the phenomenon taking place subsequent to the deposit of the pollen on the stigma, which results in the union of the protoplasms (*fovilla* and *oosphere*) of the male and female cells. All flowers have a specific time when fertilization can be accomplished, and this is called the waiting stage or *anthesis*. This, as to duration, varies greatly, depending altogether on the species, in some only a few hours, while in others, it may last for days.

Somewhere during this stage the pollen grain gets to the stigma and is held there securely by an adhesive secretion. Influenced by this moisture, it germinates; thus the living inner coat breaks through the inert outer coat and elongates itself into the form of a delicate tube containing the fovilla; this penetrates now the loose tissue or the canal of the stigma and style, feeding all the while upon the surrounding nourishing liquids, and finally reaches the ovary. There may be but one pollen tube from each pollen grain, but pollen of some plants emit twenty or more. These tubes sometimes are very short, then again many inches long; are unicellular and always extremely thin.

One or two of these pollen tubes now enter into the micropyle of each of the ovules and here is discharged the protoplasm of the pollen grain (sperm cell) upon the protoplasm of the ovule (germ cell), thus causing fertilization. The time occupied in this transit in some flowers is only a few hours, while in others it may be days, weeks or months (Orchids). From the inception of the pollen on the stigma the ovule begins to make preparation for its reception, and at once forms an *embryo sac*, to which the pollen grain attaches its extremity upon its arrival. The protoplasm of the two living cells having mingled, we get as a resultant a particle of living matter in juxtaposition to the apex of the pollen tube. This globule now becomes a new centre of growth. At first it becomes turbid, and expands to a proper cell. It now, by division and subdivision, multiplies itself, forming new cells or units, each having nucleoli, cell-walls, etc., and begins to assume form varying as to the species, thus showing distinctively the caulicle, radicle (which always points towards the micropyle of the ovules) cotyledon and plumule, and thereby completes the *embryo*. In the case of the Coniferæ, where no stigma exists, the pollen falls directly into the micropyle of the naked ovule. The pollen then forms tubes, through which the fovilla passes in order to come in contact with the minute cells in the ovule.

The number of pollen grains produced, and the number apparently necessary for absolute fertilization, presents quite an interesting contrast. Thus a

floret of wheat contains about 7,000 pollen grains; a single Dandelion flower about 240,000; each stamen of a Pæony 21,000; a single Wistaria produces 5,750,000 stamens, containing altogether 27,000,000,000 pollen grains, which would be 7,000 grains to each ovule. A single bloom of Maxillaria F. = 34,000,000 pollen grains and 1,756,000 seeds. The Orchis mascula contains in each bloom 120,000 pollen grains.

The amount, on the other hand, required for impregnation is infinitely less; thus, to fecundate Hibiscus Trionum fruit containing 30 ovules, requires 50–60 pollen grains. The ovary of Datura, Dianthus, Lychnis and Nicotiana may be completely fertilized by the pollen of a single anther. In Geum 8–10 anthers out of 84–96 contained in each flower suffice to fertilize the 80–130 ovules in each ovary. The pollen of different plants does not possess vitality for the same length of time; thus, the Nicotiana species will fertilize only for 48 hours after maturing: the Datura = 2 days; Dianthus Caryophyllus = 3 days; Lobelia splendens = 8 or 9 days; Cheiranthus Cheiri = 14 days; Orchis abortiva = 2 months; Candollea = 1 year; Palms, such as Date and Chamærops humilis, = 1–18 years. Pollen retains its fecundating property longer when left in the anthers, and the finer it is the sooner it becomes worthless. In transporting plants which are dependent for fertilization upon certain insects or animals, from their native country to other localities, it is quite essential to convey also these pollinizing agents, or else

the propagation and thriftiness of the species will be interfered with. It is true the plant may endeavor to use the next best adaptation, but this does not always succeed, and often results in the extinction of the kind.

In *Cryptogamous* plants propagation is mostly by several methods of *conjugation*, etc. In Yeast plant the processes of reproduction and nutrition are all in one cell. This divides as to its contents, bursts, thus discharging germs capable of producing new individuals. In the Mould and Fungi we have several cells, one or more nutritive and others reproductive. In Diatoms, and as we advance to the higher Crytogams, the reproductive cells have true functions, and these may unite by conjugation, which union gives a cellular embryo or spore (Spirogyra, Zygmema, etc.). These reproductive cells are of two kinds, either situated together or apart on the same or different individuals; one of these represents the *male*, the other the *female*. The former is the analogue of the *anther*, and is termed the *Antheridium*, (pl. antheridia) (ἀνθηρὸς, flowery + εἶδος, form), a cellular body having free cells enclosing *Antherozoids* or *Phytozoa* (φυτὸν, plant + ζωὸς, living), which are minute movable bodies, thread-like, floating in a mucilaginous liquid. The latter is the analogue of the pistil (ovary) and is termed the *Archegonium*, (pl. Archegonia) (ἀρχὴ, beginning + γόνος, offspring) or *Pistillidium*. This contains cells which, after contact with Antherozoids, are able to germinate. These may sometimes have cilia,

when they are called *Zoospores* (ζωὸς, living + σπορά, seed or spore = moving spores). The Antherozoids having similar functions to spermatozoa in animals, are also called *Spermatozoids* (σπέρμα, seed). When the contents of the *antheridia* and *archegonia* come in contact, a cellular body is produced in the latter, which cell or germ, when mature; may be either discharged or may remain intact with the plant until further developed.

The names of the sexual organs among cryptogamic plants are quite changeable in the hands of various writers; thus, in Fungi we have *conidia* (κὸνος, dust), also *zygosphore* (ζυγὸν, a yoke), which is a compound spore; also *cystidia* (κύστις, a bladder) = another name for *antheridia*, and *oogonia* (ὠὸν, an egg + γόνος, offspring) = another name for *archegonia* or *sporangia*, in which, after the action of the antheridia, a fertilized spore is formed called *oospore*. In Lichens we have small hollow sacks = *spermagones*, which contain *spermata* = another name for *spermatoroids*. In Algæ we have male organs = *androspores*; also *zoospores* (asexual generation); these give rise to confervæ with definite sexual organs (archegonia and antheridia); also have *globule* (antheridium) and *nucule* (nucula, a small nut) = archegonium.

While fertilization produces such important changes on the interior of the ovules, it must not be lost sight of that the exterior is also very much modified; thus, the ovary is always more or less enlarged and the walls are somewhat transformed. External organs are very much affected, hence

often the stamens and corolla drop off even before the pollen reaches the ovules, while the calyx receptacle and bracts frequently feel the influence. The flowering stage is but the acme of the plant's existence, to accomplish which all the nutritive processes are taxed to their utmost, and this is such an effort and so exhaustive in some species that flowers are seldom perfected, hence years elapse in some cases between flowering periods. The fertilization changes are likewise very depleting to the plant, of which it often very quickly gives evidence. At the *period of expectancy* the plant seems at its best, and it can be kept blossoming for a very long time, provided the pollen be kept away from the stigma.

CHAPTER XI.

THE FRUIT.

The Pistil, after having received the pollen which the anthers have discharged, continues to grow and enlarge until finally it is matured in the form of the peculiar fruit of the plant. The stigma and style generally are *deciduous*, while other organs may grow fast to the ovary in developing (Calyx, etc). *The Fruit then is the ripened ovary with adnate parts.* While the structure of the two resemble, at the same time, the ovary has been materially modified in this stage of transition mainly to facilitate, when ripe, the seed dispersion. Such changes are:

1. *The loculi of ovary may decrease* by abortion (Buckeye, Hazel, Oak have in the flower three, but in the fruit only one).

2. *The loculi of ovary may increase* by false partitions (Stramonium capsule in flower = two, but in fruit = four cells; Cassia Fistula, likewise, with one-celled ovary is converted into a many-celled fruit.

3. *External surface may change* (Stramonium ovary in flower = soft and hairy; in fruit = covered with sharp prickles. Maple in flower = two-lobed; in fruit = have on each lobe wing-like appendage).

4. *The ovary wall may change in consistency.*

(*a*). May become thin, papery (Bladder-senna).

(*b*). May become hard and bony (Pericarps of many capsules).

(*c*). May become tough and leathery (Lemon, Orange rind).

(*d*). May become externally hard, internally soft (Gourd).

(*e*). May become externally soft, internally hard (Cherry, Peach).

(*f*). May become succulent throughout (Gooseberry, Grape).

5. External organs often adhere (Apple, Gooseberry, Melon, Pear, Quince). Wintergreen has the calyx, which is truly the edible portion. Rose has concave receptacle, lined inside with carpels and calyx adhering. Strawberry has the receptacle to become thick, succulent and edible. Dandelion, Thistle have the calyx limb modified to pappus, allowing the wind to move it easily. In the Acorn, Filbert, Hazelnut, the fruit consist of pistil, calyx and bracts, while Pineapple = ovaries, perianths and bracts of several flowers. Fig = many separate flowers enclosed in a hollow, fleshy receptacle. The rich colors and pleasant taste of fruits often cause animals to eat them, flesh and seeds; these latter, being indigestible, pass through the system and are frequently deposited in favorable conditions for germination. Animals may also disperse easily the seeds of those fruits having hooks and spines as accessories (Bidens, Desmodium, Lappa, etc.).

Dispersion of fruits, and consequently seeds, is accomplished by—

1. The Wind. Such as are light and buoyant by having wings—pappus—thin and flattened shapes (Dandelion).

2. Water Currents or Waves. Such as have exterior impenetrable by and will float on water (Cocoanut).

3. Hygroscopism. Such as have various portions at the same time to absorb or dissipate water differently. This property thus weakens and finally ruptures the pericarp, when the seeds are scattered, frequently with considerable force and noise (Hamamelis, Sandbox, Touch-me-not). Some grasses twist and untwist according to amount of moisture, and this motion serves sufficiently to drive fruit into soil or scatter spores to the wind (Equisetum, Liverworts, Porcupine Grass).

4. Animals. Such fruits as have bright colors, pleasant taste, hooks, spines, barbs, adhesive pericarps, can easily be dispersed by such animals as birds, squirrels, etc. (Bidens, Burdock, Desmodium, Mistletoe, Stickseed = Steckseed).

Classification.

I. AS TO COMPOSITION.

1. Simple. Here the fruit is a single ripened ovary, or with calyx tube incorporated (Cherry, Cranberry, Gooseberry).

2. Aggregate. Here a cluster of carpels of the same flower are crowded into a mass (Blackberries, Raspberries).

3. ACCESSORY. Here adnate parts make up a portion of the fleshy mass (Blackberry, Buffalo-berry, Strawberry, Wintergreen).

4. MULTIPLE. Here several flowers have consolidated into one mass, including receptacle, floral envelopes, bracts (Mulberry, Pineapple).

II. AS TO CONSISTENCE.

1. FLESHY = those soft and juicy thoughout—

(*a*). *The Berry* (L. *bacca*) = Blueberry, Cranberry, Currant, Gooseberry, Grape, Orange, Tomato.

(*b*). *The Pepo* (Gr. πέπων, a pumpkin) or *Gourd-fruit.* = Hard-rinded berry of gourd family = Cucumber, Melon, Pumpkin, Squash.

(*c*). *The Pome* (L. *pomum*, an apple) = like berry; but main flesh is calyx = Apple, Pear, Quince. The Hawthorne = drupaceous pome.

2. STONE OR DRUPACEOUS (L. *drupæ*, unripe olives) = those having an outer part fleshy like a berry, the inner stony like a nut (Apricot, Cherry, Date, Mango, Nutmeg, Peach, Plum, Walnut). The Drupe has no subdivisions, but has specific names for its various portions; thus,

Epicarp (Gr. ἐπί, upon, outside + καρπός, fruit) = external layer or mere skin.

Mesocarp (Gr. μέσος, middle) = middle layer or fleshy part.

Endocarp (Gr. ἔνδον, within) = internal layer or stone. In the Date, the brown skin = epicarp; pulpy flesh = mesocarp; the papery layer covering the seed = endocarp. In the Walnut, the hard

shell = endocarp; the green husk = mesocarp, and epicarp; same with Orange. More frequently the first two are taken together under the name *Sarcocarp* (Gr. σάρξ, flesh) or *Exocarp*, while the stone is known as *Putamen* (L. *putamen*, a shell) or *Endocarp*. The term Drupe applies to stone fruit, whether it be from a simple or a compound pistil. The fleshy part of this corresponds to the lower, and the stone to the upper face of the component leaf or leaves.

3. DRY = those having no flesh or pulp—

1. *Indehiscent—one-seeded.*

(*a*). *The Akene* or *Achenium* (Gr. α, not + χαίνω, I open) = this is a small, dry, one-seeded indehiscent fruit, often taken for a naked seed (Ranunculus). See Fig. 14 = akene of a Buttercup. We can trace this to the simple pistil form, as it either possesses the remains of a style or stigma, or a scar from which this has fallen, a distinguishing point from seeds (Anemone, Boraginaceæ, Clematis, Labiatæ). Such an akene is called *superior*, but when the calyx closely adheres in form of *Pappus* it is called *inferior* (Compositæ, Dandelion, Lettuce, Thistle, etc.).

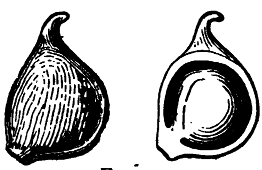


FIG. 14.

(*b*). *The Cremocarp* (Gr. κρεμάω, I hang). This is the fruit special to the Umbelliferæ. In the blossom it resembles the inferior akene, but, upon ripening, it splits apart into two closed carpels having longitudinal ridges, and between these, oil

tubes. Each half is called a Mericarp or Hemicarp.

(*c*). *The Utricle* (L. *utriculus*, little womb or bag) is a superior, one-celled, one- or few-seeded akene, but the pericarp is bladdery, thus fitting the fruit (seed) loosely (Chenopodium). When ripe, it may discharge its seeds by bursting open irregularly or by a circular line around its greatest circumference, the upper part falling off like a lid (Amaranthus).

(*d*). *The Caryopsis* (Gr. κάρυον, nut + ὄψις, appearance) *or Grain*. This is like the akene (superior, one-celled, one-seeded), except the pericarp closely adheres to the seed, making thus the fruit and seed incorporated into one body (Corn, Oats, Wheat, etc.).

(*e*). *The Nut or Glans* is a dry, indehiscent, inferior, one-celled, one (or two)-seeded fruit having a hard, crustaceous or bony pericarp, partly or entirely enclosed in an involucre (Acorn, Chestnut, Cocoanut, Hazelnut). This involucre in the Acorn is a kind of cup at its base and is called *cupule*. In the Chestnut, the cupule forms the bur; in the Hazel, a leafy husk.

(*f*). *The Samara* (L. *samara*, seed of Elm) or *Key-fruit* is either a superior akene—a nut, or any other indehiscent—fruit having its pericarp extended into a wing-like appendage (Ash, Elm, Maple, Sycamore).

2. *Dehiscent—single pistil—several-seeded.*

(*g*). *The Follicle* (L. *folliculus*, little bag). This is a dry fruit, one-carpeled, and only dehisces down one side, *i. e.*, along the ventral suture, and

consequently is one-valved (Columbine, Larkspur, Marsh Marigold, Milkweed, Pæony).

(*h*). *The Legume* (L. *legumen*, pulse) or *true Pod.* This differs from the follicle in the dehiscence occurring along both the ventral and dorsal suture, forming two halves, called *valves*. The seeds are always borne on the ventral suture (Leguminosæ).

(*i*). *The Lomant* (L. *lomentum*, bean meal) is a modified legume having constrictions between each seed, which finally divides itself along these in transverse segments (Acacia, Hedysarum, Ornithopos, Sanfoin).

3. *Dehiscent—compound pistil—several-seeded.*

(*j*). *The Capsule* (L. *capsula*, little chest) is a dry, dehiscent, superior fruit of any compound pistil, discharging its seeds either *by pores* (Antirrhinum, Poppy) or by *bursting irregularly* somewhere (Lobelia, Snapdragon), or by *splitting regularly* into as many or twice as many valves as there are carpels (Colchicum, Chickweed, Datura, Iris), or *transversely* (Henbane, Pimpernel), or only *partially* (Dianthus, Lychnis, Mignonette). Capsules may be *one-celled* (Gentian, Heartsease, Mignonette), *two-celled* (Scrophularia), *three-* or more *celled* (Colchicum, Datura). Shape often varies, as in Helicteres = five spirally twisted carpels; in Illicium anisatum = carpels in stellate shape.

(*k*). *The Pyxis* (L. *pyxis*, a box) is a kind of capsule having the upper portion or lid separating from the lower by a circular horizontal line; dehiscence here called *circumscissile* (Hyoscyamus, Purs-

lane, Plantain). When dehiscence is not entirely around, the upper and under parts are joined with a hinge (Jeffersonia).

Indehiscence. These are fruits that do not open at maturity, such as fleshy and stone fruits. The seeds here become free only by the flesh decaying or being eaten by animals. All such fruits depend upon outside agents for disseminating their seeds.

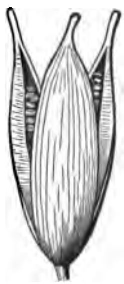


FIG. 15.

Dehiscence (L. *dehisco,* I open). These are fruits that open at maturity, either along the *ventral suture* (see Fig. 15=Pod of Marsh, St. John's Wort, with Septicidal dehiscence, thus dividing themselves through the partitions or septa of component carpels and called *Septicidal* (L. *septum*+*cædo,* I cut) (Rhododendron, St. John's Wort), or along the *dorsal suture,* thus dividing themselves down the back of each component carpel into the loculi or cavities of the cells, and called *Loculicidal* (L. *loculus, cell* + *cædo,* I cut)(Iris). Some capsules possess both kinds (Rose, Spurge). Either kind may have the valves to break away from the partitions, but these remain attached to the axis of the fruit; this is called *Septifragal* (L. *septum* + *frango,* I break) (Datura, Morning Glory).

(*l*). *The Silique* (L. *silqua,* a husk or pod) is a kind of capsule, superior, many-seeded, elongated, two-valved, and these valves separate from the base upward, leaving the seeds attached to the two parietal placentas, which are united by a spurious

verticle dissepiment called a *replum* position (Cabbage, Celandine, Mustard, Wallflower).

(*m*). *The Silicle* (L. *silicula*) or *Pouch* is a short and broad silique (Shepherd's Purse).

Of Multiple Fruits, which are products of flower clusters, and not of simple flowers, we have several kinds—

(*n*). *The Sorasis* (Gr. σωρός, a cluster). is a collective fruit where the inflorescence (flowers) in ripening has fused itself together into a fleshy mass (Mulberry, Pineapple).

(*o*). *The Syconium* (Gr. σῦκον, a fig) or *Fig-fruit* consists of a succulent, hollow receptacle or stem, lined with a multitude of minute flowers, becoming akene-like nuts. May be *dryish* (Dorstenia), or *pulpy*, or *luscious* as in the Fig.

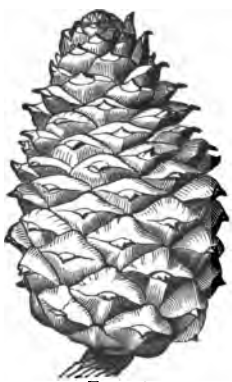


Fig. 16.

(*p*). *The Strobile* (Gr. στρόβιλος, fir cone) or *Cone* has a scale-bearing axis, and each scale encloses one or more seeds (Cypresses, Hop, Pines, etc). See Fig. 16 = cone of a common Pitch Pine. These scales may become succulent as in Juniper Berry. In the Hop, or *true strobile*, the seeds are distinctly enclosed in a carpel situated at the base of each scale; in the *true cone* the seeds are more or less exposed.

CHAPTER XII.

THE SEEDS.

The seeds are the fertilized and ripened ovules—they are the final product of the flower to which all other parts are subservient, and to which end the whole life and function of the plant seems to be particularly concerned and directed.

The seed generally has a great resemblance to the ovule from which it is transformed. The *chalaza* (Gr. χάλαζα, *a tubercle*), the *rapha* (Gr. ῥαφή, a seam), the *funiculus* (L. *funis*, a cord), the *hilum* or *umbilicus*, and the *foramen* (here called *micropyle*) (Gr. μικρός, small + πύλη, gate) all exist and are recognizable in the seed. The position of the two are identical in the ovary and the fruit, while the names anatropous, campylotropous, etc., apply equally to both. Though this be true, it is evident that the ovule has undergone important changes, not only in size but in shape and structure, while being developed into the seed. The most important of these are:

1. *The seed coats*, though retained in the seed, often take on many alterations.

(*a*) *The outer seed coat* changes from what was smooth, thin, and membranous in the ovule to a thick and variously marked one in the seed, being known then as the *testa* (L. *testa*, a shell); thus this

may become *crustaceous*, *smooth*, *polished* (Adenanthera); *netted* (Nasturtium); *reticulate*, *wrinkled* (Nigella); *striated* (Tobacco); *rugose*, *tuberculated* (Chickweed); *alveolate* or *pitted* (Poppy); *fissured*, *furrowed* (Delphinum); *spiny* (Mulberry); *hairy* (Gossypium). This testa may fit the kernel tightly or be expanded into a *wing* (Sandwort, Trumpet Creeper); this wing may be divided into *shreds* or *tufts* (Bignonia, Catalpa, Moringa), or it may consist of a *tuft of long, soft hairs* attached to a particular point, when it is called a *coma* (Asclepias, Epilobium, Milkweed, Willow), or this may cover the entire seed with its *long hairs* or *wool* (Bombax, Cotton). These render seeds buoyant, so as easily to be dispersed by the winds. Such *appendaged seeds* are only found in the dehiscent fruits. Other kinds of appendages often occur; thus we have an outgrowth from the funiculus or placenta, which gives an additional, more or less incomplete covering outside of the real seed coats called the *aril* or *arillus* (L. *aridus*, dry)=Celastrus, Euonymus, Nutmeg, White Water Lily, or this may be in the form of a short, thick, cellular excrescence at or close to the hilum, when it is called the *caruncle* (L. *caruncula*, a small piece of flesh) Ricinus, Sanguinaria. The outside coat is sometimes also *converted into mucilage* (Flax, Quince). The color of the testa is generally *brownish* (Almond), although it may be *white*, *yellow*, or *black* (Canna, Pæony, Poppies), or *reddish* (Arnatto, Barricarri), or *spotted* (Castor Oil, French Beans).

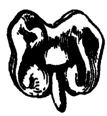
(*b*). *The inner seed coat*, when present, is thin, delicate, membranous, and is called the *tegmen* (L. *tegere*, to cover). Sometimes this is absolutely wanting, but in other cases it coalesces unrecognizably either with the *outer coat* or the *kernel.*

2. *The Kernel* undergoes internal structural changes. This may consist entirely of the *embryo* when the texture is the same throughout, and the seed is said to be *exalbuminous*—here the embryo occupies the entire seed; and all the nourishment is of one consistence; being stored up in the cotyledons (Acorn, Almonds, Bean, Pea, and most edible nuts), or the *kernel* may consist of the embryo, together with a white, mealy material composed of cells containing *starch*, *albumenoids*, *oily matter*, etc., which, from its resemblance to the white of the egg, was named by Gærtner *albumen*, and these seed consequently are termed *albuminous.* Here the nourishing material is of two consistencies: the inner is soft, snowy white, and is developed immediately outside the embryo but within the embryo-sac, and is called *endosperm*; the other is deposited outwardly from this, on the outside of the embryo sack, and is called *perisperm.* It is this that constitutes the albumen, and the amount present varies greatly in different seeds; it may be equal to the embryo when it is said to be *equal;* if greater = *copious*, if smaller = *scanty.* We occasionally have *perispermic albumen* (in nucleus outside the embryo sac) and *endospermic albumen* (within embryo sac alone) = Chelidonium Major, Ranunculaceæ, Umbelliferæ, and many endogens,

both kinds may occur in the same seed = Nymphæaceæ, Piperaceæ. The texture of this albumen also differs; it may be *farinaceous* or *mealy* (Buckwheat, Oats, Wheat, etc.); it is *fleshy* when it can be cut easily (Barberry, Cocoanut, Heartsease); it

FIG. 17.

FIG. 18.



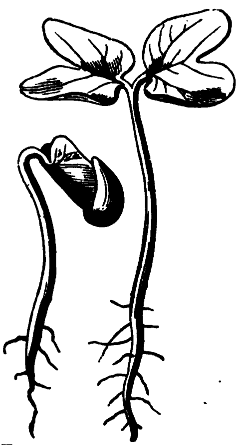


FIG. 19. FIG. 20.

may be *oily* (Bloodroot, Croton, Poppy, Ricinus); it may be *horny* (Coffee, Date, Nux Vomica); it may be *bony* (Ivory Palm), and it may be of marbled appearance, with transverse fissures, when it is called *ruminated* (Anonaceæ, Nutmeg). It is the floury part of Cocoanut, Coffee, Corn.

We have the *albuminous seed*, with a well-developed embryo distinctly represented in Figs. 17–20 inclusive. This is the common Morning Glory (Ipomœa purpurea). Fig. 17 is a longitudinal section of the seed, through the embryo's centre as it lies, crumpled in the albumen. This substance is pulpy or mucilaginous in young seeds, but hardens as the seeds become ripe; then again returns to the pulpy condition in germination, thus liquified, the thin cotyledons can easily absorb it by their entire surface. It supplements the nutritive material contained in the embryo, and by the conjoined substance in embryo and albumen the seedling is established, having root, stem and a

pair of leaves for beginning independent growth.

Fig. 18 is the embryo taken out of the albumen and unfolded, the broad and very thin cotyledons notched at the summit, and the caulicle below.

Fig. 19 is the early state of germination, while Fig. 20 is the same in a more advanced stage; caulicle or primary stem, cotyledons or seed-leaves, and below the root well developed.

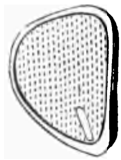
The Embryo is the essential part of the seed or kernel; it is really the young plant having all the parts for growth, as has the larger tree, and for the perfection of this embryo the flower, fruit and seed exist; it is the finished product of the reproductive process. It is well developed in *exalbuminous* seeds as a general thing, but is smaller and with less perfect parts in the *albuminous* seeds.

The position of the embryo in the seed is constant as to the radicle always pointing to the micropyle, but varies greatly in reference to the albumen. Thus it may be *straight, and buried in the albumen* (Cat-tail, Nux-vomica, Violet); it may be *curved within the albumen* (Hyosciamus, Moonseed, Pink); it may be *curved, lying on the outside of and surrounding the albumen* (Lychnis dioica), or it may be placed to *one side of the albumen* (Indian Corn).

The well developed embryo, like the bean, consists of *four essential parts*. 1. The *caulicle* or stemlet. 2. The *radicle* (L. *radix*, *root*) or root which springs from the lower end of the caulicle. 3. The *cotyledons* or seed leaves, which are located near the upper end of the *caulicle* (L. *cauliculus*, a

little stalk) these are in this case thickened, homologous bodies, holding the food upon which the little plantlet starts life, consequently, can be either *fleshy* or *foliaceous*. 4. The *plumule* (L. *plumula*, a little feather) or feathery bud occurring between the cotyledons. Thus we find in this embryo all the growing organs on a diminutive plan. The cotyledons may resemble and do the work of leaves (Maple, Morning Glory) but more commonly they are disguised, being thickened with nourishing food for the plantlets' use, (Oak, Pea). In this case they do not rise above ground in germination, but remain where planted till all nutriment is exhausted, then decay and disappear. These are called *hypogeal* cotyledons, while those rising above soil and acting as foliage are called *epigeal*.

FIG. 21.



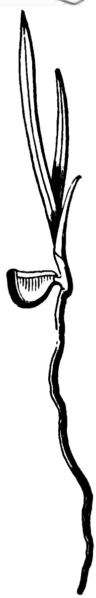


FIG. 22.

FIG. 23.

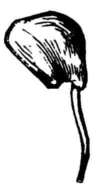


FIG. 24.

Monocotyledonous embryos are those having only one seed-leaf, and this is convoluted around itself, enclosing and protecting within its folds the delicate plumule. The various parts of these embryos are frequently not very clearly differentiated and not so apparent as those of the dicotyledons (Indian Corn, Grasses, Lilies, Sedges).

Figs. 21–24 inclusive are of Monocotyledonous plants. Here Fig. 21 is a section of the Iris or Flower-de-Luce seed, so enlarged as to show its small embryo in the albumen, near the bottom. In germinating, the whole lengthens enough to push the lower end of the caulicle out of the seed, from this end the root is formed, and from the upper the plumule emerges.

Fig. 22 is the same germinating seedling further advanced; here the plumule is developed into the first four leaves (alternate), the first one rudimentary; the cotyledon remains in the seed.

Fig. 23 is a section of an Onion seed magnified, showing the slender, coiled embryo in the albumen, while Fig. 24 is the same in early germination.

Dicotyledonous embryos are those having two opposite seed-leaves which are held in contact by an outside testa; between these we have enclosed the clearly differentiated parts (Beans, Chestnuts, Melons, Oaks, etc.).

Figs. 25–34 inclusive are of Dicotyledonous plants. Here Fig. 25 is a section of a Pæony seed with very small embryo in the albumen near the end.

FIG. 25.

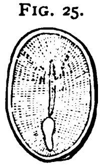


FIG. 27

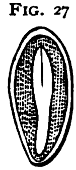


FIG. 29

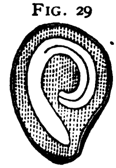


FIG. 26.

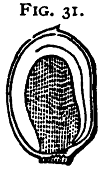
FIG. 28.

FIG. 30.

Fig. 26 is the same embryo detached and more magnified.

Fig. 27 is a section of a Barberry seed, showing straight embryo in the middle of the albumen, while Fig. 28 is its embryo detached. Fig. 29 is a section of a Potato seed having embryo coiled in the albumen, and Fig. 30 is its embryo detached. Fig. 31 is a section of the Mirabilis or Four-o'clock seed, with embryo coiled round the outside of the albumen, and Fig. 32 is its embryo detached, showing the incurved, broad, leaf-like cotyledons facing each other. Fig. 33 is the embryo of Abronia umbellata; one of the cotyledones very small, and Fig. 34 is the same straightened out.

FIG. 31.



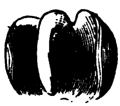


FIG. 32.

FIG. 33.

FIG. 34.

Polycotyledonous embryos are rather rare and are but modifications of the dicotyledons, where the cotyledons are increased to *three*, *four*, *six* or *fifteen*, all in a whorl from the summit node of the caulicle (Coniferæ, Pines).

Acotyledonous embryos are also occasionally met with, and are but a modification of the dicotyledons in which the cotyledons are aborted or wanting (Dodder, etc.).

Sometimes we find dicotyledons with only one cotyledon, the other having been aborted (Abronia). Here we must exercise care in not mistaking these for monocotyledons, both of which are very distinguishable from one another by other external characteristics. These cotyledons have very many

shapes and positions, thus they may be *straight*, or *folded*; or *rolled up* as are the leaves in an ordinary bud. In the latter case they may be rolled up either *from one margin* (Colycanthus), or *from apex* in a flat spiral, or they may be both *folded* (plicate) and *rolled* (convolute) as in Sugar Maple.

In Cruciferæ the edges of the flat cotyledons either lie against the radicle, which is termed being *accumbent*, or the radicle lies against the external side, or the back of one of the cotyledons, which is termed as being *incumbent*.

The vitality of the seed is phenominally great, all of which is due to the fact of its embryo being living but inactive material. Maize and rye have been known to grow when forty years old; Kidney beans when one hundred; Raspberry when seventeen hundred; Mountain Potentilla when sixty; some, however, hardly retain vitality a year (Coffee Magnolia).

The number of seeds varies with different plants, a single Poppy capsule has been found to contain forty thousand seeds, and this plant is not near so prolific as some others. If all the seeds were to take root and reproduce, it would take but a few years for the entire earth's surface to be so covered as to leave room for no other living thing. But with them it is the same as in the more developed plant and animal life; they have to contend with circumstances, such as animals, insects, soil, climate, dampness and moisture, so that for their propagation it is alone the "*fittest that survive.*"

CHAPTER XIII.

GERMINATION.

Germination.—This is the *secondary growing stage* which takes place after the embryo has been in a dormant or quiescent state. All the parts begin anew to develop, and in a comparatively short time give us a plant like its parent. Two conditions are absolutely necessary in order that seeds may germinate, viz., that *warmth* and *moisture* be supplied. While this can be effected by suspending seeds through the agency of wire frames, in glass vessels partly filled with water, and then placing these near the ceiling or in a room of uniform temperature of say 80° F.; at the same time the usual method is by *planting* the seeds in the ground and covering them with sufficient earth to supply not only *warmth* and *moisture*, but also *shade*.

Warmth is essential for all vital activity, and when desiring any or all kinds of germination, be that animal or vegetable, the *place where* must unconditionally have the temperature from 65° to 90° F. It is true we have from this rule a few isolated exceptions where extremes are endured and life still exists. Thus, in the boiling Geysers of Iceland and our West (190° F.) several species of Chara have been found growing and fruiting, while in Greenland and on the snow-capped peaks of Mt.

Hood, Mt. Washington, and other lofty ranges, many species are found growing and flowering.

Moisture is supplied in the rain and dew, and is also essential because it not only facilitates circulation, but when the integuments absorb it they become soft, enlarged, and at the same time it causes the insoluble starch of the cotyledons and albumen to be converted into soluble sugar, whereby the growing embryo is further developed and nourished. For this conversion we need O from the air, as it unites with a portion of the C of the starch to produce heat to evolve CO_2, while it converts the remaining starch into soluble and nutritive grape sugar. The various steps in germination may be briefly described as follows:

1. *Dicotyledons*, Fig. 35. — After planting such a seed we first notice the caulicle (radicle) protruding from the micropyle or from the opened cotyledons. The crumpled plumule (*p*) is still closely folded, but the cotyledons (*c-c*) have a slightly changed appearance as to consistency. The caulicle then gives forth the radicle (*r*), which descends into the soil, while the caulicle is directed upwards towards the surface, bringing along with it the cotyledons, which by this time have shed their seed-coats and appear as a pair of green leaves. Lastly, the plumule opens up above the surface as a green bud having its first internode, and in a short time furnishes a pair of typical leaves for continuing the

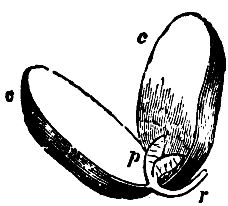


FIG. 35.

absorption and elaboration of plant-nourishing material. This is no longer an embryo but a growing plant, with a perfect descending and ascending axis. The same description applies to the Beech; Maple, Oak, Pea, Squash, and all other dicotyls—the only variation being *in the disposition of the cotyledons*. These mostly come to the surface and act as the first pair of leaves (Bean, Maple), but when very thick they never escape their seed-coats, and remain in the identical spot where originally planted till all the nutrient substance is appropriated to the advancement of the caulicle, radicle and true leaves.

2. *Monocotyledons*, Fig. 36.—This represents the Indian Corn, and in all this class the cotyledon is not disengaged from the seed, but remains stationary with it wherever planted. The caulicle protrudes, and from it several rootlets are developed, which descend into the ground. The plumule, being the upper portion, shoots at first parallel with the cotyledon along the face of the seed, then ascends, pushing out leaf from within leaf. The same method applies to Tulip, Wheat, etc.

FIG. 36.

The reason why the roots always grow downwards is as yet unsettled. Some think it due to gravitation, others to their aversion for light, but the most

rational explanation is that its growth or cell development takes place most readily on the moist side of its growing point, and hence in a downward direction, so long as the soil in contact with its lower surface is more moist than that above. This accounts also for the proverbial tendency of roots toward springs and water courses.

EXERCISE IN ANALYSIS.

1. *For Pollination*, collect and compare the anemophilous flowers, Corn, Plantain, Timothy, Wheat, with the entomophilous flowers, Apple, Buttercup, Geranium, Pink, noting (*a*) *the variation of stigmas, the kind and quantity of pollen, the colors and perfumes;* (*b*) *those proterandrous, proterogynous* or *normal.* (*c*) Among Pinks notice *difference between staminate and pistillate stages.* (*d*) Do anthers of Buttercup dehisce *extrorsely* or *introrsely*, and how does that effect cross fertilization? (*e*) Blue Flag, note position of *nectary, anthers, stigmas, dehiscence; how is cross-fertilization effected?* (*f*) Barberry, Lady Slipper, Mallow, Milkweed, Pea: note *stamen and petal arrangement, anther structure, dehiscence, shape of stigma, position of nectary.* (*g*) Polygala polygama, Viola blanda and Viola odorata, in the fall; *examine the runners under the leaves for cleistogamous flowers; count the seeds.*

2. *For Seed:* (*a*) Almond, Bean, Pea, Pumpkin, Stramonium; *study anatomically, locating each part.* (*b*) Bean, Corn, Horse Chestnut, Maple, White Pine: soak in warm water until the seed coats are easily removable, when examine *which are albuminous and exalbuminous, what the position of the albumen and name the parts of embryo present?*

3. *For Fruit:* (*a*) Apple, Banana, Beet, Butternut, Carrot, Corn, Osage Orange, Raspberry, Stramonium: *give classification.* (*b*) Agrimony, Cleavers, Clotbur, Dogbane, Elm, Garden Balsam, Geranium, Grape, Hounds Tongue, Wild Cucumber. *Study these as to their adaptation for being dispersed.*

Recapitulation.

- **POLLINATION—FERTILIZATION** =
  - Close Fertilization,
  - Cross Fertilization, =
    - Anemophilous,
    - Entomophilous, =
      - Dichogamy,
        - Proterandrous.
        - Proterogynous.
      - Heterogony,
  - Hybridization,
- **FRUIT** =
  - FORMATION,
  - DISPERSION,
  - CLASSIFICATION, =
    - Composition,
    - Consistence, =
      - Fleshy = Berry, Pepo, Pome.
      - Stone = (Sarcocarp, Putamen.)
      - Dry =
        - Akene, Cremocarp, Utricle, Caryopsis, Nut, Samara, Follicle.
        - Legume, Lomant, Capsule, Pyxis, Silique, Silicle, Sorasis, Syconium.
        - Strobile.
  - DEHISCENCE.
  - INDEHISCENCE,
- **SEED** =
  - CHALAZA,
  - RAPHA,
  - FUNICULUS,
  - HILUM,
  - MICROPYLE,
  - SEED COATS,
  - KERNEL, =
    - Exalbuminous,
    - Albuminous,
      - Vitality of Seed.
      - Numbers of Seed.
  - EMBRYO, =
    - Caulicle,
    - Radicle,
    - Cotyledons, =
      - Monocotyledonous Embryo.
      - Dicotyledonous Embryo.
      - Polycotyledonous Embryo.
      - Acotyledonous Embryo.
    - Plumule,
- **GERMINATION**
  - Warmth,
  - Moisture,

CHAPTER XIV.

Organs of Vegetation or Nutrition.

(ROOTS, STEMS, LEAVES AND HAIRS OR TRICHOMES.)

THE ROOT.

The Root is the basis of the plant and the organ through which most of the plant's nutrition is supplied. Of these we have several kinds, viz.:

First, as to Origin.

1. **The Primary Root** is the one that the caulicle first produces, hence is embryonic.

(*a*) *Single Primary Root.* — Here the initial identity is always preserved—does not divide—and for that it frequently receives the name *Main or Tap Root.* If it has any branches, they are, comparatively speaking, insignificantly small, unless main root is injured, when one or several may become enlarged (Carrot, Oak, Radish).

(*b*) *Multiple Primary Roots.*—Here the caulicle produces from the first a cluster of roots and not a solitary one (Plantain, Pumpkin = *fibrous,* and Dahlia = *fleshy.*)

2. **The Secondary Roots.**—These are produced from other portions of the stem (especially from nodes = *adventitious*), when such portions are screened from light and supplied with moisture.

The inclination is just as great for stems, when covered with soil, to give off roots as it is for roots to branch and to send off fibres; particularly is this noticeable when stems, having freshly cut ends, are used. This fact gives rise to *propagation* by (*a*) *division;* (*b*) *layering;* (*c*) *cuttings.*

Second, as to physical appearance.

Both Primary and Secondary Roots may be either Fibrous or Fleshy.

1. **Fibrous Roots.**—These serve mainly for absorption, and are slender or thread-like (Corn, annuals, many perennials). Frequently these send off branches irregularly, called *rootlets.* The newer and fresher these are the more moisture, hence nutrition, is absorbed from the soil. This is mostly controlled by the degree with which the organs above ground (stem and leaves) grow and expand. So long as moisture escapes from freshly expanded foliage, just so long will new underground surface be created. When supply and demand are unequal, the growing conditions are not best; so that when growth ceases above ground, the leaves die and fall off, and the root-hairs, being servants of the leaves, annually perish, while the roots harden their tender tips and also cease growing. For this reason, then, is it best to do all transplanting during the quiescent stage (from late autumn to early spring). These root-hairs arise from the tender epidermis or skin and perish when that thickens into bark. They are the main absorbing agents, and when cut in digging, the roots are prevented

from doing normal work, but the leaves continue the same as usual; hence plant withers and dies. The absorbing surface exposed by the roots, rootlets and root-hairs is, in most plants, comparable in extent with the surface exposed by the leaves to the air; in other words, there is a hand-to-hand equilibrium between subterranean and supraterranean expansions.

2. **Fleshy Roots** are those which become a storehouse of nourishment (Biennials, Carrot, Turnip). In these, the food created during the first year is utilized for the plant's rapid second year's growth, which culminates in *flowers*, *fruit* and *seed*. By the time these are produced, the root and whole plant dies.

Fleshy Roots may be *single* or *multiple*, and according to their shape we recognize special names, viz.:

1. *Conical.*—When shape of a cone = thickest at the crown and tapering gradually to a point at the other end (Aconite, Carrot, Parsnip). (See Fig. 37.)

2. *Napiform* (L. *napus*, turnip).—When greatly thickened above and abruptly becoming slender, producing thus the length and width about equal (Cyclamen, Turnip). (See Fig. 39 = Turnip.)

3. *Fusiform* (L. *fusus*, spindle).—When thickest in the middle and tapering towards either end (Beet, Radish). (See Fig. 38 = Parsnip.) Some consider all these roots of Cyclamen, Radish, Turnip, etc., as enlarged stems, but the weight of authority opposes it. All these are *fleshy succulent*

FIG. 37.

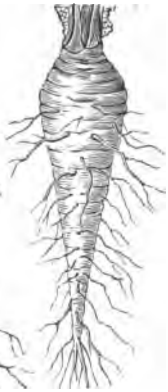


FIG. 38.

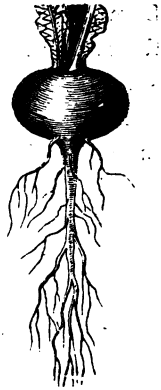


FIG. 39.

primary roots, but we also have *fleshy secondary roots* in the form of Sweet Potatoes, etc. These are propagated by adventitious buds. Dahlia produces fascicled roots also, but no adventitious buds. These are propagated by the budding of the surviving base of the stem.

Anomalous Roots (Gr. ἀνώμαλος, irregular). These subserve other uses than *absorption*, *food-storing* or *fixing plants to the soil.*

1. *Aerial* or *Adventitious Roots* (confined mostly to warm, moist climates).—Here roots strike from the stem high up, and endeavor to reach the ground (Banyan, Mangrove, Indian Corn, Sugar Cane). The two former have these reaching the ground, which serve as supporting columns, and assist the true root in obtaining food; these often form the entire support of the stem when the lower part of this decays. Thus a tree becomes a grove sufficiently large to shelter an army.

2. *Aerial Rootlets.*—Confined mostly to climbing plants, and are of service mainly in attaching the stem (from which they grow along its entire length) to a support such as trees or house walls (Ivy, Poison Ivy, Trumpet Creeper).

3. *Epiphytes* (Gr. ἐπί, upon + φυτόν, plant) or *Air Plants.*—These have no connection with the soil, but derive their sustenance from the air alone. Their roots are green, possessing true epidermis and stomata, and serve to fix them to supports, and also absorb their food from the air (Epidendrum, most Orchids, Tillandsias, etc.)

4. *Parasites* or *Parasitic Plants* (Gr. παρά, beside + σιτîεν, to feed).—These bury their roots into the juices of the plant upon which they grow, and in that way thrive at the disadvantage of the host (Beech-drops, Dodder, Mistletoe, Pine sap). Some plants are only *partly parasitic;* thus they have most of their roots acting in the ordinary way, while the remainder form suckers at their tips by which they grow fast to the roots of other plants and thus rob them of much nourishment (Gerardia).

5. *Saprophytes* (Gr. σαπρός, rotten + φυτόν, a plant).—These plants grow solely on decayed animal or vegetable matter in the soil; otherwise, are the same as parasites (Fungi, Indian Pipe, etc.).

Duration of Roots = ANNUALS, BIENNIALS, PERENNIALS.—The first and second applies not only to roots but equally as well to stems, while indeed we sometimes speak of plants as even being perennials.

(1). *Annuals* are herbs. These spring from

seed; blossom, mature their fruit and seed, then die and decay, all within one season (from spring to fall = their growing year). When winters are mild and moist, may have *winter annuals*; these perish in the following summer. The roots of all such plants are always small (Grasses, etc.).

(2). *Biennials* (L. *bis*, twice + *annus*, year).—These grow from seed the first season without blossoming, but lay up during this time a stock of nourishment in the roots, etc. The stem then dies down to the ground, the underground parts retain their vitality, but are quiescent during the winter, yet in the spring they put forth rapidly another stem, then *blossom*, *seed* and *die*. The roots of biennials are generally large at even the end of the first season, and such stored nutritious matters are used up by the plant in the second season for producing its *flowering* and *fruiting* functions (Carrot, Turnip).

(3). *Perennials* (L. *per*, through + *annus*, year).—These live and blossom uninterruptedly year after year (Dahlia, Orchis, Woody plants, etc.).

The herbs in cold climates die down to the ground yearly, but enough of the subterranean portions always live to give new development every spring. The trees and shrubs have their stems and branches above ground to continue growth even during the winter. Changing climates often makes annuals out of perennials, and *vice versa*, the perennials of warm countries becoming annuals of cold latitudes (Ricinus communis).

The Differences between Roots and Stems.

The Root has characteristic functions, viz.: 1. To support the plant in position, fix it to the soil. 2. To imbibe from the soil the food necessary for the growth of the plant. The stem is but a connecting link between the root and the plant's laboratories (leaves). 3. The root is the *descending axis;* the stem is the *ascending axis.* 4. The root bears no leaves; the province of the stem is to bear leaves. 5. Roots have no growing nodes or internodes; stems, on the contrary, possess these—that part of the root joining the stem = *base*; the opposite extremity = *apex.* 6. Roots branch very *indefinitely*; stems by regular order—*definitely.* 7. The growing point of the root is back of the apex = *subapical*; that of the stem is *apical.* Hence it is a wise provision for roots to have their tenderest cells covered by the *root-cap,* as thereby hard earth can be penetrated without risk of injury. 8. The root inclines to grow downward, to get further away from the light; the stem seeks the light, and, place the seed at whatever disadvantage, the stem will use every effort to come to the surface. 9. Roots always grow from stems and not the converse. It is the stem (caulicle) that is the first evidence of development in embryo, and that gradually elongating in regular sequence from it, we have given off, beginning first with the root, all the other plant organs.

CHAPTER XV.

THE STEM.

The Stem bears all other organs, but its distinctive office is to bear leaves, Branches are secondary stems.

We divide stems into two classes, viz., those above ground = *supraterranean*, and those under ground = *subterranean*.

1. **Supraterranean Stems.**—These by the very early writers were divided, which division is still in use, according to *age*, *texture* and *size*, and thus named *Herbs*, *Shrubs* and *Trees*. The first have their stems dying down to the ground at the approach of winter, while the two latter have permanent woody stems, consequently remain from year to year. To be more precise and comprehensive we have the following descriptions:

First, as to Consistence.

(*a*) *Herbaceous.*—Dying down to the ground yearly.

(*b*) *Suffrutescent* (L. *suf* or *sub*, under + *frutex*, shrub, bush).—Somewhat woody below, and from that point surviving year after year.

(*c*) *Suffruticose* (L. *suffrutex*, under shrub), or *Frutescent*, have low stems which are woody below, but herbaceous above.

(*d*) *Fruticose* (L. *frutex*, shrub) or *Shrubby* = *woody*—lives from year to year; 15 to 18 feet in height (Iva frutescens).

(*e*) *Arborescent* (L. *arborescens*, to become a tree). Approaching a tree in size and appearance; not above 25 feet in height (Rhododendron arborescens).

(*f*) *Arboreous* (L. *arbor*, tree), forming a proper tree trunk (Oxydendrum arboreum).

Second, as to size.

Stems differ widely—from mosses that have stems $\frac{1}{25}$ inch long and a diameter of a fine thread, to the giant trees Sequoia of California and Eucalyptus of Australia, which have a length of four or five hundred feet, and a diameter of very many feet.

Third, as to shape.

In this they differ widely. The typical form is *cylindrical;* then we have *triangular* (Rush), *quadrangular* (Labiatæ, Scrophulariaceæ), *jointed* (Grasses), *fluted* (Parsnip, Valerian), *fusiform* (Palms), *broad but thin disk* (Dandelion), *succulent* (Cacti).

Fourth, as to duration.

Some attain full size in a few days, while in a few days more they completely disappear. On the other hand, many are a long time perfecting their normal growth, and endure thousands of years, and between these extremes we have every gradation. Thus the Peach tree lives only fifteen or twenty years, yet other kinds antedate the Chris-

tian era. The California Cedar—*Sequoia gigantea*—is the king among trees. One specimen measured 26 feet in diameter, 363 feet long, and had 1330 wood circles; each circle represents a year. Another had 1500 circles; another = 2130, while one was supposed to have 3200, and measured 60 feet in diameter.

Fifth, as to Direction of Growth.

(*a*) *Erect*, when growing vertical or upright and continuing so (Rhynchosia erecta, Trees).

(*b*) *Diffuse*, when loosely spreading in all directions (Boltonia diffusa).

(*c*) *Declined*, when turned or bent over to one side (Stellaria humifusa).

(*d*) *Decumbent*, when reclined on the ground as if too weak to stand (Potentilla supina, Sagina decumbens).

(*e*) *Assurgent* or *Ascending*, rising obliquely upwards (Ranunculus ambigens, Astragalus adsurgens).

(*f*) *Procumbent* or *Prostrate*, lying flat on the ground from the first (Ribes prostratum, Sagina procumbens).

(*g*) *Creeping* or *Repent*, prostrate on or just under the ground and striking root (Clover, Epigæa repens, Partridge berry).

(*h*) *Climbing* or *Scandent*, ascending by clinging to other objects by tendrils, rootlets or twisted leaf stalks: 1. Celastrus scandens, Grape, Passion flower, Pea, Calumba, Pareira; 2. Ivy, Poison Ivy, Trumpet-creeper; 3. Virgin's Bower.

(*i*) *Twining* or *Voluble*, coiling spirally around other stems or supports (Berchemia volubilis, Hop, Morning Glory).

We have distinctive names for certain stems having special uses.

A Culm or *Straw Stem* is jointed (Grasses, Sedges). It may be *herbaceous* (Rye, Wheat) or it may be *woody* (Bamboo, Cane).

A Caudex or *Palm Stem* also represents an upright and thick rootstock, is scaly and unbranched (Palms, Tree Ferns).

A Sucker is an ærial shoot that springs from a stem under ground (Mint, Raspberry, Rose). Hence these are creeping branches under ground which give rise to propagation by division.

A Stolon is where a stem or limb becomes prostrate or declined, the end of which, on coming in contact with the moist soil, takes root, at the same time sends a stem up in the air and thus gives rise to a new plant (Currant, Gooseberry, Trifolium stoloniferum). This has given origin to the gardener's *layering*.

An Offset—a short stolon or sucker with a crown of leaves at the end (Houseleek).

A Runner—a creeping stem which takes root at its extreme tip; here a bud or a tuft of leaves is formed; hence a new plant, which in turn sends out new runners to act in the same way.

Tendrils are slender branches without buds or leaves, intended only for climbing (Cucumber, Grape-vine, Passion flower, Pumpkin, Virginia

Creeper). These grow straight till a support is reached, when the end hooks itself to this securely; then the tendril shortens itself by making coils, thus drawing the shoot of the growing plant nearer the supporting object. Other tendrils have adhesive, flat, disk-like tips in order to clinch rocks, walls, etc. Some tendrils are leaves or parts of leaves (Pea); then they are not in axillary position, but in that of the true leaf.

Spines or *Thorns* are stunted and hardened stems (Hawthorn, Honey-Locust). Here the leaf bud, instead of forming a symmetrical leaf-bearing branch, has its growth arrested; it sometimes also bears leaves. Spines may be indurated leaves, when their situation under an axillary bud reveals their true nature (Barberry).

Prickles and *Warts* are excrescences of the bark and not of the stem. They are chiefly large multicellular hairs, hardened by lignin deposit, and spring from the true epidermis and the layer of cells just beneath (Blackberry, Bramble, Rose).

2. **Subterranean Stems.**—These were formerly confounded with roots, and are, at the present time, so designated by the laity in common language, but in reality they only mimic the habits of roots, from which they can be easily distinguished by bearing scales or scars, in the axils of which buds occur, and their growing point is apical, consequently have terminal buds. We have four kinds, viz.: RHIZOME, TUBER, CORM, BULB.

(1) *The Rhizome* (Gr. ῥιζοῦν, to take root) or *Root-stock* is a creeping, underground stem; grows horizontal, oblique or erect (Scabiosa succisa, Cicuta verosa); marked on upper side with scales, scars or withered remains of previous years' stem (one for each year) and sends off roots mostly from under surface. The terminal bud is usually conspicuous. (See Fig. 40 = Rhizome of Solo-

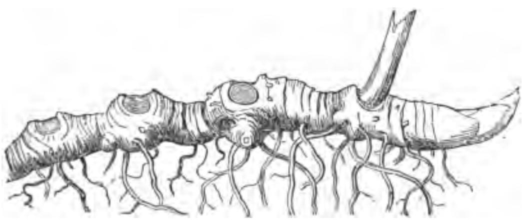


FIG. 40.

mon's Seal, with the season's stalk and the bud for next year's growth. The rhizome may be *slender* and *extensively creeping* (Carex, Couch-Grass, Mint), or it may be *thickened* and *fleshy* from starchy deposits (Calamus, Ginger, Sanguinaria, Solomon's Seal). These are all perennials, and through this fact many of the former kind may serve a useful or useless purpose. Thus the Carex arenaria so spread and anastomose the sea shore as to prevent any denudation from the receding waves, while the Triticum repens furnishes an absolute pest to the farmer, inasmuch as in his endeavor at extirpation every division made with the hoe only serves to form an independent plant possessing a node capable of develop-

ing a leaf-bud and roots. The rhizome may be considered a *series of corms* united by more or less elongated internodes.

(2) *The Tuber* (L. *tumere,* to swell) is a short, thick underground stem, being swollen by the deposition of starch or other nutritious matter, and is borne usually at the end of a slender, creeping branch, having leaf-buds or eyes on the sides. Here the nodes of the stem approximate and the internodes swell (Artichoke, Potato). Fig. 41 are the tubers of Helianthus tuberosus = Artichokes.

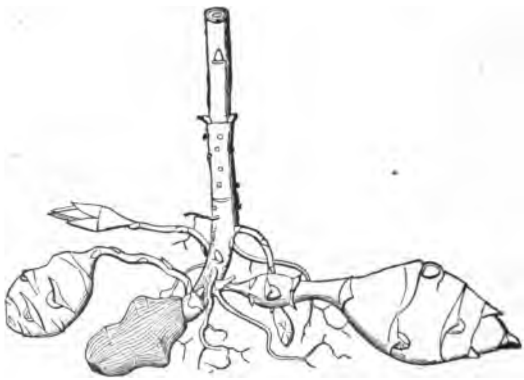


FIG. 41.

The creeping branches die in the autumn, thus setting each tuber free, and capable of producing many plants the succeeding season. The Potato has three forms of branches: 1. Those bearing leaves with which to elaborate food; 2. Sometime afterwards a second set of branches bear flowers, fruit and seed, using the food for this, which

the leaves have heretofore digested; 3. The largest portion of this nourishment, while in liquid form, goes down the stem into a third sort of branches underground and accumulates as starch at their extremities. By this provision the so-formed tubers can reproduce much easier than seeds.

(3) *The Corm* (Gr. κορμός, the tree trunk) or *Solid Bulb* is an excessively short, thick, fleshy underground stem, often broader than high, having leaves and stalks given off from upper surface and roots from under surface (Colchicum, Crocus, Cyclamen, Gladiolus, Indian Turnip). Fig. 42 is the Crocus Corm divested of the dead leaf-bases. The faint cross-lines represent the scars where the leaves were attached = the *nodes*, and the spaces between are the *internodes*. The previous years' exhausted corm is underneath, and those forming for next year are on the summit and sides. Corms are always annuals, and by some are considered bulbs, in which the stem is much enlarged and the scales reduced to thin membranes. The buds produced by the corm go into young corms by using up all parental material as nutriment; these younger corms in turn produce their new corms, these likewise destroying their parents, and so the repetition is continuous; by this process each succeeding corm comes nearer the earth's surface. Crocus buds from apex, Colchicum from the side

FIG. 42.

near its base. These contain starch and other nutritious matters.

(4) *The Bulb* (Gr. βολβός, a bulb) is a stem like a reduced Corm as to its solid part, but this is covered with thick, fleshy scales, which constitute its main bulk. Hence this is a bulb with fleshy scales on a short stem. In the three preceding the food is in the stems, but here it is in the bases of the leaves (Lily, Onion, Tulip). Fig. 43 = bulb of Wild Lily. The true bulb is only found in Monocotyledons. We have two kinds of bulbs, viz.:

FIG. 43.

(*a*) *Scaly Bulbs*. These have thick, fleshy and comparatively narrow scales which, however, overlap one another, but have no outer dry scales (Lily).

(*b*) *Tunicated Bulbs* (L. *tunicatus*, coated with layers) are those where the scales enwrap each other, forming concentric coats; the *inner* scales are thick and fleshy, the *outer* ones thin and membranous (Hyacinth, Onion, Squill).

BULBLETS are small bulbs growing from large ones under ground, or from axils of leaves above ground (Leek, Lilies, Onion). These are buds with thickened scales; never become branches, but when detached will root, thus forming new plants. These differ from ordinary buds in being fleshy, and by spontaneously separating from their

parent and reproducing, while from true bulbs they differ in being smaller and ærial. These occur on Dicotyledons as well as Monocotyledons.

Consolidated Vegetation.—The *tree system* is on the plan that develops an extensive surface; on the contrary, all these *subterranean stems* have their more enduring portions concentrated in the smallest possible form and best shape to contend against drought, heat or cold. Trees, even of hot and dry climates, cannot afford as much branching or foliage as those of colder and moist countries. Even here the tendency of nature is to protect herself by providing against possible contingencies. These compact stems are so shaped that, in the *growing period*, they expand large surfaces to light and air; but, during the *resting period*, the living part is reduced to a globe, which has the least possible surface for any similar amount of solid substance, and this is protected by outer coats of dead and dry scales. Besides that, it is under the ground. All this allows life to exist, although climatic conditions may be the most unfavorable. These can endure excessive sun and droughts, but when the rainy spell comes, they grow forth all the more rapidly, as though desiring to make up *for lost time.*

CHAPTER XVI.

BUDS.

These truly may be considered rudimentary stems, with primitive leaves compactly arranged upon them, and for convenience may be divided as follows:

First, as to Contents.

Buds are of two kinds, viz.:

1. *Leaf bud*, which contains the rudiments of a *leafy stem*, *shoot* or *branch*; and

2. *Flower bud*, which contains the same component parts metamorphosed into the incipient floral organs for the purpose of reproduction. In the earliest stages of growth, it is difficult to recognize whether the protoplasmic point is ultimately to become the *one* or the *other*, but later on a complete differentiation becomes manifest and easily visible.

Second, as to Position.

Buds are also here of two kinds, viz.:

1. *Terminal*, which are those affording stems to increase in *length*. These exist in embryo (cotyledons + plumule), and so long as growth takes place, it is at the summit (Cycas, Palms).

2. *Lateral or Axillary* are those by which lateral or side branches are produced, thus giving increase

plants in *breadth*. These become terminal as soon as their development is fairly under way; consequently each branch or shoot has a terminal bud like the parent or main axis, and will extend its growth in length as long as uninjured. If, however, destroyed by frost or violence, or if converted into a bloom, increase in that direction is forever at an end. The name *axillary* is significant of the fact that they always occur in the *axils* of leaves. These can be *active* or *passive;* in either case they are formed in early summer on the new growth of the stem, and may go into branches of considerable length at once, or in the following spring, when they would be considered *active*, or they may lay dormant from year to year, never showing any activity, and without warning they may suddenly, upon favorable conditions, begin to grow into branches, thus producing an irregularity both in position and time, when they would be considered *passive* or *latent*. The suppression of such buds tend to produce plants of simple forms, having a branchless trunk of considerable height crowned with a solitary tuft of leaves. If terminal bud is injured, the highest axillary bud comes to the rescue and continues extension of the part as best it can.

Third, as to Irregularity.

Buds sometime occur without method. Of these we have two kinds, viz.:

1. *Adventitious* or *Accidental* buds are those that

are neither terminal nor axillary, but grow anywhere on the plant: in the internodes of stems and branches, on the roots, or even on the leaves. These generally are a result of local injury, inasmuch as nature, in her effort to repair, sends an abundance of nourishing materials to such scarified points, and from the plus quantity of such these buds have their creation. When the Osier Willows are pollarded, it is these buds that give such a crop of adventitious twigs so suitable for basket and other similar work. These buds occur on the *stems* of such trees as Chestnut, Elm, Poplars, Willows; on the *leaves* of Begonias, Bryophyllum, Walking Ferns—here the leaves, after being shed, produce marginal buds, which root and form new plants—and from the *roots* of some species of the Poplar we frequently have shoots sent up some distance from the main trunk all out of adventitious buds.

2. *Accessory* or *Supernumerary* buds are where, instead of one true axillary bud, we have several clustered, most commonly side by side of the true and larger bud, and only distinguished from this by their smaller size (Apple, Hawthorn, Red Maple), or they may be placed less commonly, one over the other, having the upper one most developed (Butternut, Cherry, Honey, Honeysuckle, Locust, Walnut).

Fourth, as to Consistence.

Here we have two kinds of buds dependent upon the character of the outside envelope, viz.: *Scaly*

and *Naked*, and these can be either terminal or axillary.

1. *Scaly buds* belong to vegetation where growth is suspended for cold winters; during such seasons these scales serve to protect the inner delicate parts by keeping out cold and regulating the effects of sudden changes. Such woody leaves contain but little water, hence are bad conductors of heat; besides this, they are sometimes clothed with downy hairs and covered with an insoluble varnish or resin; thus provided, they are sealed up, as it were, from changes of temperature and from the ingress of water, ice, snow, etc. (Horsechestnut, Maples.)

2. *Naked buds* are those whose scales are inconspicuous or wanting, and naturally belong to tropical vegetation—to most herbs and shrubs. These are sometimes wholly or partially concealed beneath the corky layer of the bark (Hobble-bush, Kalmia). The leaf scars of the subtending leaves to these buds, created by the leaves falling away in the autumn are, for the most part, prominent, and wherever seen we might naturally expect a shoot or a bud growing from the axil, but the symmetry is far from being as complete as that of the leaves. These are either *opposite* or *alternate*, and while buds should be likewise, they have such a number of contending influences to oppose, that many in their earlier stages are deprived of sufficient nourishment or light, in consequence of which they succumb to their stronger allies and

thus perish, leaving vacant and apparently unbroken that which should have been their space.

Definite annual growth is generally from strong winter buds; these contain all the leaves and very short stems, which latter have only to lengthen quickly, so that in a few days or weeks its whole growth is attained, and then it forms and ripens its buds for the succeeding year's growth (Hickory, Horsechestnut).

Indefinite annual growth is generally from summer buds whose continued growth is stopped by frosts of autumn, etc., in consequence of which they do not form or ripen any terminal or upper axillary buds, protected by scales, hence the succeeding year's growth takes place from the lower axillary buds, which, comparatively speaking, are quite mature.

Deliquescent growth is where *axillary buds* and *branches* take the lead in any given plant. The main stem or trunk soon divides into many branches, giving us plants and trees with rounding or spreading tops (American Elm).

Excurrent growth is where the *terminal bud* or *stem* continues to develop year after year, presenting a continuous and an uninterrupted shaft. Such a tree may have limbs, but they are quite distinguishable from being a part of the main trunk. All such trees are tall, slender and spiral shape (Firs, Spruces).

CHAPTER XVII.

THE LEAF.

Leaves are solely *stem appendages*, originating just back of the stem's apex, in the cellular tissue; are regularly arranged upon it at points (nodes), and consist of *expansions of its bark tissue*. They are primarily the organs of *digestion* and *respiration*, although they occur in a variety of forms, thereby secondarily subserving various uses.

The common or *typical leaf* is an expanded green body, flattened, bilaterally symmetrical (? inequilateral = Begonias, Pilocarpus, Senna, etc.), having distinct upper and under surface. Its function is *to expose* to the air and light the materials which the plant absorbs by its roots, etc.; *to exhale* certain portions of these, and *to assimilate* the residue for its own growth and nourishment.

We have very many modifications of this type, any of which may occur on the same individual plant with the normal. Indeed, no other organ is susceptible of so many disguises in its maturity, both as to shape and application, but in its incipiency we cannot distinguish its bud from one that is to become *a spine, a tendril, a stamen* or *a pistil.* All begin with a small *papilla* just back of the stem's growing apex.

Leaves differ from stems in their growth, by usually *completing first their apex and afterwards their base;* they invariably appear in *acropetal order* (Gr. ἄκρος, summit+L. *petere*, to seek) ; *i. e.*, the oldest being lowest on the stem, and they always *subtend* (=*i. e.* beneath) stems and other buds. *We understand, then, that anything is a leaf that occupies this leaf position.* The upper angle formed between the leaf and the stem is called its *axil* (L. *axilla*, armpit), and everything arising from that point is termed *axillary*.

The typical leaf has three parts.

1. *Lamina, Limb* or *Blade*, which is the broad expanded surface. It consists of green soft parts (parenchyma) supported by woody fibrous frame (prosenchyma) called *ribs* or *veins*, all covered by an *epidermis.* See Fig. 44, *b*.

2. *Petiole* (L. *petiolus*, a little foot or stalk) or *Foot Stalk*, which is the narrow basilar portion, usually *cylindrical*, but may be *flattened.* When leaves do not have this, they are called *sessile.* See Fig. 44, *p*.

The petiole varies in length, generally shorter than the lamina, though sometimes 15–20 feet long and may be firm enough for walking sticks (Palms). It is mostly *rounded*, while upper portion is *flattened* or *grooved.* It may be *compressed laterally*, causing the leaves to tremble (Aspen), or in aquatics, it may be *distended with air* for floating (Pontederia, Trapa), or it may be *winged* (Lemon, Orange), or it may have a *leaf-like appearance* (Dionœa, Nepenthes).

3. *Stipules.* These are small leaf-like expansions, always in pairs, one being on each side of the petiole's base. When these are absent, the leaf is said to be *exstipulate.* See Fig. 44, *st.*

VENATION means the arrangement of the veins or framework of the leaf. These veins are usually *woody and hollow* to allow strong support, and the circulation of sap to every portion of the lamina. The large central one is called *mid-rib,* and the next in size respectively *ribs, veins* and *veinlets.*

In such plants as Mosses there are no veins, as their leaves consist of only a layer of green cells, but in all higher ordered vegetation these are distinctly prominent.

We have two principal kinds of *vein distribution,* viz. : *Net-veined* and *Parallel-veined.*

I. NET-VEINED (*Reticulated*) (L. *rete, reticulum,* a net) LEAVES.—These have a pronounced *mid-rib,* from which many branches irregularly radiate, all of which anastomose with each other. Of these we have two varieties:

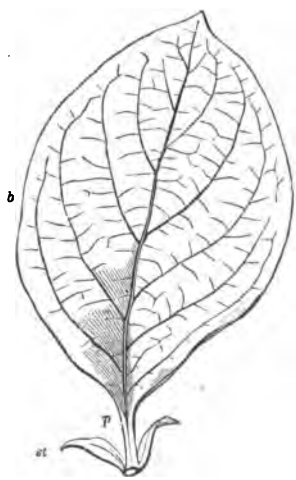


FIG. 44.

1. *Feather-veined* (*Penni-veined* = *Pinnately-veinea*) (L. *pinna,* a wing or leaflet).—Here all the

veins arise from a single mid-rib, like unto the plume of a feather on each side of its staff (Belladonna, Digitalis, Hyoscyamus, Maple, Quince). Fig. 44 is the Quince leaf showing this kind of veining in a single rib leaf.

2. *Digitately* or *Radiate-veined* (*Palmately-veined* (L. *palma*, the palm of the hand), diverging from the petiole like fingers from the palm of the hand).—Here the veins branch from *three*, *five*, *seven* or *nine* prominent ribs, which divide off from the top of the petiole, and for the most part run the length of the lamina; these frequently are apportioned so that one large rib is in each lobe or segment of the lamina, provided the leaf is not entire (Basswood, Buttonwood, Cimicifuga, Delphinum, Maple, Podophyllum, Ricinus, White Poplar).

Netted Venation belongs to Dicotyledonous plants; these are Exogens, and have their flowers mostly in fours or fives.

II. PARALLEL-VEINED LEAVES. — These have the veins running parallel and straight, or nearly so, and do not anastomose with each other. Fig. 45 is the leaf of the Lily of the Valley illustrating this parallel ve-

FIG. 45.

nation. Linnæus called these *nerves* in contradistinction to *veins*, which he claimed solely belonged to the *netted variety*. These, however, being one and the same thing, it is of too little importance to observe such a distinction; they were so named in resemblance, as thought, to the human anatomy. Of parallel venation we have two varieties, viz.:

1. *In this kind* the ribs run from *base to apex* and are the most common (Indian Corn, Iris).

2. *In this kind* the ribs run from *mid-rib straight to the margin* (Banana, Calla, Pickerel Weed).

Parallel Venation belongs to Monocotyledonous plants; these are Endogens, and have their flowers in threes (never in fives).

LEAVES may be conveniently classified into two forms—*simple* and *compound*. Both classes include leaves of numerous shapes and outline, and as these differences afford characters by means of which frequently plants are distinguished and species named, it becomes quite important that the significance of each should be thoroughly understood.

SIMPLE LEAVES are those that have a *single lamina* and *one articulation with the stem.*

COMPOUND LEAVES are those having their *lamina divided into two or more* distinct subdivisions called *leaflets*, each one of which *articulates with the main leaf stalk*, and usually has a stalklet. We have two kinds of Compound Leaves:

I. PINNATE = those having leaflets arranged along the sides of a main leaf stalk. These answer

to the *Feather-veined simple leaf.* Fig. 46 represents a Compound Pinnate leaf, from which its three following varieties can be well illustrated :

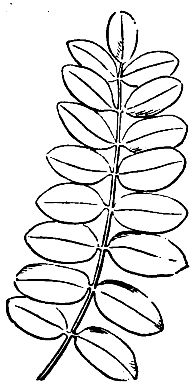


FIG. 46.

1. *Pari-pinnate* (abruptly pinnate) = two leaflets opposite, at the summit (Acacia, Copaiba, Senna, Tamarindus).

2. *Impari-pinnate* (odd pinnate) = leaf terminates with a single leaflet at apex (Glycyrrhiza, Juglans, Myroxylon, Picræna, Pilocarpus, Pterocarpus).

3. *Cirrhosely-pinnate* (L. *cirrhus,* a lock or curl, tendril)=leaf is terminated by a tendril (Adlumia cirrhosa, Brunnichia cirrhosa).

II. PALMATE=Those in which leaflets are all borne on the tip of the petiole. These correspond to the *palmate simple leaf* (Æsculus, Clover, Coptis, Lupinus, Virginia Creeper). Fig. 47 represents a compound Palmate leaf of the Sweet Buckeye, having five leaflets. Each kind of Compound Leaves may have any number of leaflets, but pinnate usually have more than palmate. The former in-

Fig. 47.

clines to give long and narrow leaves, while the latter give short and broad. These leaflets present all the variations in shape and contour as do simple leaves. Thus the same names (entire, serrate, etc.) apply equally to both. These leaflets may further divide, thus making the leaf double or twice compound, and this may be *pinnate* or *palmate* (twice, thrice or decompound).

In describing the number of leaflets, we can use the terms unifoliate (L. *unum*, one+*folium*, leaflet), bifoliate, trifoliate, etc. Inasmuch as the same irregularities and variations extend alike to *simple* and *compound* leaves, the detailed descriptions that follow, including names, are to be considered as occurring in and belonging to both kinds.

First, as to Shape,

Regardless of marginal irregularities.

Linear = narrow, elongated, parallel margins, several times longer than wide (Drosera linearis, Grasses, Marsh Gentian).

Lanceolate (L. *lancea*, a lance) or *Lance-shaped* = longer than wide—wide at the base and tapering to apex (Viola lanceolata, White Willow).

Oblanceolate = or inversely lance-shaped = apex wide and tapering to the base (Chimaphila).

Oblong = three or four times as long as broad (Bladder Senna, Ranunculus oblongifolia).

Elliptical = longer than wide, with rounded ends and sides (Hypericum ellipticum, Lily of the Valley).

Oval = broadly elliptical, having length two or three times its breadth (Pear tree).

Ovate = shape of hen's egg, the broader end being the base (Chickweed, Cinchona ovata, Lilac).

Obovate or inversely ovate = having the broader end at the apex (Buchu, Cassia obovata).

Spatulate = large and round apex, thence tapering to base, like old-fashioned spatula (Daisy, Rudbeckia spathulata, Uva ursi).

Cuneate or *Cuniform* (L. *cuneus*, a wedge) (*Wedge-shape*) = broad at apex and tapering by straight lines to an acute angle at base (Rubus cuneifolius, Saxifrage).

Second, as to Base.

Cordate (*Heart-shaped*) = ovate with a deep sinus at the petiole attachment (Black Bryony, Cinchona cordifolia, Dog-violet).

Reniform (L. *renes*, kidneys) (*Kidney-shaped*) = rounder than cordate and broader than long (Asarum, Nymphæa reniformis).

Auriculate (L. *auricula*, little ear) (*Ear-shaped*) = having a small ear on either side at the base (Gerardia auriculata, Solanum dulcamara).

Sagittate (L. *saggitta*, an arrow) (*Arrow-shaped*) = having ears acute and turned downwards, while main body tapers to a point at apex (Arrowhead = Sagittaria sagittifolia, Viola sagitata).

Hastate (L. *hasta*, a halberd) (*Halberd-shaped*) = having ears acute and turned outwards (Rumex acetocella).

Peltate (*Shield-shaped*) = having petiole attached near the centre of the lamina (Podophyllum peltatum, Ricinus communis).

Third, as to Apex.

Acuminate (*Pointed* or *Taper-pointed*) = having summit prolonged into a tapering point (Coffee, Ficus religiosa, Magnolia acuminata).

Acute = ending in an acute angle—not having a prolonged point (Cassia acutifolia).

Obtuse = with a blunt or rounded apex (Cassia obtusa).

Truncate = with apex cut off square (Tulip tree = Liriodendron tulipiferum).

Retuse (L. *retusus*, blunt) = with a broad shallow sinus at apex (Hæmatoxylon, Red Whortleberry).

Emarginate (*Notched*) = decidedly indented at the apex (Pilocarpus, Tephrosia).

Obcordate (*Inversely Heart-shaped*) = obovate leaf, with apex deeply incised.

Cuspidate = apex tipped with a hard, sharp point (Psoralea cuspidata, Rubus).

Mucronate (L. *mucro*, a sharp point) = apex abruptly tipped with a soft, small and short point (Gaultheria, Statice mucronata).

Aristate (L. *arista*, an own) (*Awn-pointed*, *Bristle-pointed*) = apex terminating in a bristle (Gaillardia aristata, Ilex).

Fourth, as to Margin.

Entire = when outline is smooth and even—without notches or teeth (Atropa, Belladonna, Orchids).

Serrate (*Saw-toothed*) = with sharp teeth pointing forwards (Barosma serratifolia, Dead-nettle).

Dentate (*Toothed*) = when teeth point outwards and not forwards (Artemisia tridentata, Viburnum dentatum).

Crenate (*Scalloped*) = teeth broad and rounded (Barosma crenulata, Ground Ivy, Horseradish).

Repand (*Undulate, Wavy*) = the margin forms a wavy line—gradually bends inwards and outwards (Holly).

Sinuate = more strongly turned inwards and outwards (Nasturtium sinuatum, Oaks).

Incised (*Cut or Jagged*) = cut into sharp, deep, irregular teeth or incisions (Acer rubrum).

Lobed = when incisions extend to half distance of the mid-rib. May have thus two-lobed, three, five, or many-lobed (Hepatica triloba, Oak).

Cleft = incisions as above, only sharp, and extending more than half way to the mid-rib (Modiola multifida, Ricinus communis). May have thus two cleft, bifid (L. *bis*, twice + *fissus*, cleft), three (trifid), four (quadrifid), five (quinquefid), or many-cleft (multifid).

Parted = incisions still deeper, but do not quite reach to the mid-rib or the base of the lamina. Here we can have two, three or four-parted, etc. (Valeriana dioica).

Divided = incisions extending to mid-rib (Papaver argemone). This is the same as compound, only each segment is not stalked and is not articulated with the mid-rib, thus making the parenchyma of the segment confluent with the mid-rib. Here we use the terms bisected, trisected, etc.

If the venation is *pinnate*, we may have pinnately-incised, lobed, cleft, parted or divided. If *palmate* venation, we follow the same order, thus having palmately-incised, lobed, etc.

It should be remembered that the lamina segments are always arranged in the direction of the principal veins. Thus pinnately veined are directed towards the midrib, palmately veined run towards the base. Hence the names *pinnatifid* (Oak), *pinnati-partite* (Valerian dioica), *pinnatisected* (Papaver Argemone). If segments also divided, have *bipinnatifid*, etc., and if again these subdivided = *tripinnatifid*, etc.

Fifth, as to Surface.

Glabrous = free from hairs or protuberances of any kind (Rhus glabra).

Glaucous or *Pruinous* = covered with bloom (Arctostaphylos glauca, Cabbage, Salix).

Punctate = dotted with pellucid or other dots (Buchu, Monarda punctata).

Glandular = having glands or secreting vesicles on the surface (Ailanthus glandulosa).

Rugose = wrinkled (Eupatorium, Veratrum album).

Scabrous = harsh or rough to the touch (Humulus Lupulus, Matico).

Verrucose (or *Verrucous*) = covered with warts or protuberances.

Pubescent = covered with short, soft hair (Cassia pubescens, Cypripedium pubescens, Salvia).

Sericeous, sē-rĭsh'ŭs (L. *sericus*, silken) = covered with soft, silky hairs pressed close to the surface (Abutilon, Avicennæ, Salix sericea).

Tomentose = covered with matted or felted hairs (Arctium tomentosum, Chondrodendron tomentosum, Krameria tomentosa).

Villose = bearing long, soft, shaggy hairs (Pulsatilla, Rubus villosus).

Hispid = covered with stiff hairs or bristles (Ranunculus hispidus).

Strigose = covered with stout, sharp adpressed hairs (Rubus strigosus).

Sixth, as to Texture.

Membranous = when thin and pliable (Malva rotundifolia).

Succulent = thick and juicy (Aloe socotrina).

Scarious = dry, like bud scales.

Coriaceous = thick and leathery (Magnolia glauca).

Herbaceous = green in color and like ordinary leaves (Datura Stramonium).

Petaloid = highly colored, like petals (Cornus florida).

Seventh, as to Duration.

Persistent or *Evergreen.*—These remain green on the tree for a year or more (Cedars, Evergreens, Pine).

Deciduous = these unfold in the spring and drop off in the autumn—by frosts (Oaks, Smilax, etc.).

Fugacious (*Caducous*) = when falling off early in the summer.

CHAPTER XVIII.

SPECIALLY MODIFIED LEAVES.

I. Foliage Leaves.

1. *Perfoliate Leaves* (L. *per*, through + *folium*, leaf).—In these the stem bearing them perforates or runs through the lamina (Eupatorium perfoliatum, Uvularia, etc.). The stem occupies the centre of the lowest leaves, but gradually nears one side till, at apex, the leaves become nearly sessile.

2. *Connate perfoliate* (L. *con*, with + *natus*, born = congenitally united).—These are where opposite sessile leaves cohere by their bases, thus forming a single round or oblong leaf (Honeysuckle, Woodbine).

3. *Equitant Leaves.*—All ordinary leaves present the upper face to the sky and the lower to the earth. These, however, are not horizontal, but are perpendicular, extending thus their tips towards the sky (Calamus, Iris). Near the bottom, each leaf covers the next younger one, hence produces stradling as a horseman; hence, Linnæus named them thus from L. *equus*, a horse.

4. *Leaves with no distinction of Lamina and Petiole*, such as Cedars, Daffodils, Iris, Jonquils, Onions, Pine, Spruce.

5. *Phyllodia* (Gr. φύλλον, leaf + εἶδος, form).—Here the petiole from the beginning is so expanded as to take the place of the lamina. These can be distinguished from true lamina by their standing edgewise, the margins being directed upwards and downwards (Acacia, Eucalyptus). On the same Acacia there may occur leaves with lamina and petiole perfect, and all grades down to the simple petiole. Some petioles are in a *tendril* or *cirrhus* for climbing instead of a lamina.

6. *Falsely Vertical Leaves.*—The lamina stands edgewise to the stem, due to a twisting of the leaf's base (Compass plant, Wild Lettuce).

7. *Cladophylla* (Gr. κλάδος, a sprout + φύλλον, a leaf).—These occur in the axil of another leaf, and hence are branches with leafy appearance. They have upper and lower face, but this soon twists to be edgewise the stem (Myrsiphyllum, Ruscus).

II. Storage Leaves.—The upper and green portion of these serve as foliage, thus elaborating nourishment, while the thickened basilar portion serves as a store-house for reserving this food (Aloe, Cotyledons, Houseleek, Lily, Onion).

III. Bud Scale Leaves.—These serve to protect the inner parts, and when this purpose is fulfilled they fall off; then the shoot develops and foliage leaves appear (Dogwood, Lilac).

IV. Spine Leaves.—Here the leaves are changed into *spines* or *thorns*, which serve as a protection against predacious animals (Barberry, Cactus, Pea, Vetch).

V. Climbing Leaves or Tendrils.—Here the tips of simple leaves hook around a supporting object, or the entire leaf-stalk and leaflets may utilize themselves for such purposes (Adlumia, Clematis, Gloriosa, Maurandia).

VI. Pitcher Leaves. — Here the leaves are converted into a pouch that will hold water, by the bending of the involute margins of the broadly-winged petioles; the broad top is the lamina. These Pitchers contain water in which insects are drowned, being prevented from escaping by the deflexed hairs at the mouth. An accumulation of such makes a rich manure for the plant's individual use (Darlingtonia, Sarracenia). Nepenthes has a *tendril* for climbing, *leaf* for foliage, and a *pitcher with a lid.* Many weak-stemmed water plants (Bladderworts, etc.) have *air bladders* for buoying them up near the surface.

VII. Fly-trap Leaves.—Here the leaves are transformed into spiny, snapping fly-traps. Insects alighting on the inner face of either side cause the trap suddenly to close, frequently catching the prey. If it misses the insect, it soon opens again for another attempt. If insect is caught, it soon becomes moistened by a secretion from minute glands of the inner surface and remains closed until it is thoroughly digested (Dionæa). The Sundew catches insects by having viscid glands at the tip of strong bristles, assisted by adjacent gland-tipped bristles, which bend slowly toward the captive.

Stipules.—While a pair of these belong to every typical leaf, the majority of leaves, however, either do not possess them at all or have them fugacious or very minute. Here we observe irregularities, as we have in the lamina and petiole.

Stipules may be *free* from the petiole or *adnate*. When the two stipules unite by their margins, sheathing the stem above the insertion, this sheath is called an *Ocrea* (Polygonium).

In grasses the stipules unite with the petiole to form the sheath which encloses the stem, but usually their apices are free and slightly project at the junction of the blade and sheath, forming thus the *Legule*. Stipules, when green and leaf-like, may act as foliage (Pea). These may be bud-scales, falling off when leaves unfold (Beech, Fig-tree, Magnolia, Tulip-tree). Stipules are *spines* or *prickles* in Locust and several other Leguminosæ; they are *tendrils* in Smilax.

PHYLLOTAXY (Gr. φύλλον, leaf + τάξις, order). —This is the arrangement of the leaves upon the stem, of which we have three different modes:

1. *Alternate*, having only a single leaf at each node (Cherry, Lime).

2. *Opposite*, having a pair of leaves at each node, one opposite the other (Lilac, Maples, Mints).

3. *Whorled* or *Verticellate*, having more than two leaves at a node. If *three*, they are one-third around the stem; if *four* = one-fourth the stem. No two or more leaves ever grow from the same point (Leptandra, Silene). In *Fascicled* or

Clustered leaves, they grow from different nodes, which are very close to one another (Larch, Pines).

Alternate Leaf Phyllotaxy is the most complicated, and consequently must be considered with some detail.

In this plan, but one leaf is at each node, and they succeed each other in a spiral order. This is decidedly the most common. The different ranks can well be represented by the following common fractions: $\frac{1}{2}$, $\frac{1}{3}$, $\frac{2}{5}$, $\frac{3}{8}$, $\frac{5}{13}$, $\frac{8}{21}$, etc.

Here the numerator represents the number of revolutions around the stem before reaching a leaf standing directly above the first; the denominator represents the number of leaves in such a cycle, counting along the spiral, from any one, to the one standing directly above it; and the whole fraction expresses the angular distance of each leaf from one another around the stem. The third fraction is obtained by adding the first two, irrespective of their intrinsic valuation; the numerators for a new numerator and the denominators for a new denominator. The fourth is from the second and third, etc.

Two-ranked = distichous = $\frac{1}{2}$ = Basswood, Grasses, Elm.

Three-ranked = tristichous = $\frac{1}{3}$ = Alder, Sedges, White Hellebore.

Five-ranked = pentastichous = $\frac{2}{5}$ = Apple, Cherry.

Eight-ranked = octastichous = $\frac{3}{8}$ = Aconite, Holly, Plantain, Osage Orange.

Thirteen-ranked = $\frac{5}{13}$. Here the fourteenth leaf is over the first, after going around the stem five times = Houseleek.

Higher ranks may be observed in Pines, Spruces, etc., and these generally can be accurately distinguished. Sometimes, however, stems become distorted, and the entire number of leaves for a complete set fail to develop; even then it is not difficult to properly classify them.

Opposite Leaf Phyllotaxy.—This is simple and uniform. Each pair (180°) is placed above but over the intervals of the adjoining pair, thus making right-angles = decussate. These are next commonest (Pimelea decussata).

Whorled or *Verticellate* (L. *verto*, I turn) *Phyllotaxy.*—This is the same as opposite, only it has more than two leaves at a node, thus making the angle always less than 180°, as 90°, 45°, etc. (Lysimachia vulgaris).

Leaves of Dicotyledons are netted-veined, articulated to the stem, frequently compound, variously incised, and usually have stipules.

Leaves of Monocotyledons are parallel-veined, usually not articulated, usually simple, entire and seldom have stipules.

Leaves of Cormophytes (*Bryophyta and Pteridophyta*) may have veins at first, arranged pinnately or palmately, which afterwards become forked, usually not articulated, either sessile or stalked, frequently incised, often compound, never have stipules.

CHAPTER XIX.

PLANT HAIRS OR TRICHOMES.

Trichomes (Gr. τρίχωμα, a growth of hair) are mostly minute and simple, though in such plants as the Sundew they are complex and vascular. They are borne, without order, by the *root*, *stem* or *leaves*, being an *appendage* of their *epiderma*, although sometimes they include *hypoderma tissues*.

Their normal use is for the absorption of nourishment.—Those belonging to the roots take up by far the greater portion of the food supplied to the plant through the ground, such as liquid charged with mineral substances, etc.; those belonging to stems and leaves perform often an equally important service, in absorbing the nitrogenous compounds from the air (Geranium, Primrose, Saxifrages).

Their abnormal uses are numerous. For these purposes they are frequently modified more or less till sometimes they exist simply as abortive and functionless organs.

1. *For Protection.*—Here they may become *hardened*, *sharp-pointed* and *barbed* (Opuntia, Cactus), or even *silicated* (Mentzelia ornata); in either condition grazing animals once experiencing the painful irritation that such impart to lips and

tongue, invariably steer clear of a repeated experience. Some hairs change into *hard, sharp prickles* (Blackberry, Greenbrier, Gooseberry, Rose, etc.); others again go into *slender, stiff, stinging hairs,* having at their base an *enlarged flexible sac,* enclosing an *irritant fluid.* These entering the skin causes a pressure on, and a discharge of the sac's poisonous contents (Nettle, Wigandia urens). The bristly hairs of Tobacco, Canada Fleabane, Solanums, Mullein, and many other plants, prevent the ravages of herbivorous animals and destructive insects.

The matted hairs studding the under side of leaves *prevent insect's approach,* as well as keep the *stomata from getting clogged up* with dust and spores of destructive fungi, which, germinating, would prove very injurious to all plant life.

The younger and more tender the leaves the more abundant the hairs (Hickory, Oak, Rhododendron), while older leaves may possess none at all. *Hairs* borne on the involucre and peduncle *deter ants* and *winged insects from entering* and *robbing flowers of nectar,* which, if not the case, would prevent cross-fertilization by winged insects, as the quest of nectar is primarily their object, while it effects the transference of pollen secondarily (Catchfly, Compositæ, Thistles).

The dense hairy clothing covering many plants of dry arid regions serves to *temper the severity of the sun's rays by day,* and thus prevents excessive radiation of heat from the plant; hence chilling of its tissues at night.

2. *For dispersion of seeds and fruits.*—These are *rendered buoyant* by hairs, so that the wind can easily waft them from place to place (Cotton, Milkweed), or these are covered with hooked hairs by which they can *cling to the fleece of animals* and are thus *disseminated* (Circæa, Desmodiums, Lutetiana).

3. *For Reproduction.*—Here hairs are developed into *sporangia,* by which Ferns and other Cryptogams *reproduce their kinds.*

Hairs may be *unicellular* or *multicellular.* The former may be *simple* or *branching*; the latter may consist of a *single row* of cells placed end to end, or cells lying in a *single plane,* or of *solid masses of cells.* These multicellular hairs may be *simple* or *branching.* When either of the above kinds secrete a glutinous or odorous substance, they are called *glandular.*

Glands.—These may be divided into *external* and *internal* or *simple* and *compound.* 1. *External Glands* are on the epidermis and may be *stalked* or *sessile.* If *stalked,* they consist of either a single cell, dilated at its apex by the peculiar fluid it secretes, or of two or more secreting cells at the end of a hair, or of a mass of secreting cells. If *sessile,* they consist simply of one, two or more secreting cells. When secretions are solid they form variously shaped *warts.* When an irritating fluid is secreted at the base, hair-like processes are prolonged, thus forming a *sting* (Malpighia, Nettle). 2. *Internal Glands* are secreting cavities below the epidermis, and when in leaves can be recognized as transparent dots, projecting more or less above

the surface, containing oil, etc. (Orange, Lemon). *Nectariferous Glands* hold a position intermediate between the preceding *external* and *internal* kinds.

EXERCISE IN ANALYSIS.

1. FOR ROOT.—Take several seeds of the Lima Bean and Indian Corn, or of the Pumpkin, Pea, etc., and Iris, Onion, etc. Now suspend these in wire frames from the cork of a wide mouth bottle, one third filled with water, and place it in a uniform temperature, 80°–85° F. (see page 96), in order to cause germination. From day to day note (*a*) *the changes that take place during this growth;* (*b*) *the forms and modes of branching of the roots;* (*c*) *the root hairs and the parts having these most abundantly* (here use magnifying glass); (*d*) *the difference between roots which are primary, secondary, fibrous, fleshy, etc.;* (*e*) *the root tips in order to find the root caps*, which are specially well developed in the Duckweeds (Lemna trisulca, etc.).

Study (*b*) *Epiphytes* (Ivy, Orchids, (*g*) *Parasites* (Dodder, Mistletoe), (*h*) *Saprophytes* (Fungi, Indian Pipe) and observe the habits of their roots.

2. FOR STEM.—(*a*) In stems of Bulrush, Cactus, Dandelion, Mints, Yellow Dock, Wild Parsnip, Wheat, etc., *note distinctive shapes.* (*b*) In Hop, Morning Glory, etc., *difference in modes of twining.* (*c*) In Blackberry, Greenbriar, Wild Clematis, Rhus Toxicodendron, Pumpkin, Pea, Virginia Creeper, etc., *their modes and organs of climbing.* (*d*) In Barberry, Gooseberry, Hawthorn, etc., *their defensive organs. Are these branches or leaves thus modified?* (*e*) Take from the ground the following entire plants, Blue Violet, Bloodroot, Dandelion, Crocus, Indian Turnip, Irish Potato, Onion, Sweet Flag, Sweet Potato, Wild Hyacinth, *classify these into roots, rhizomes, corms, tubers, bulbs.*

3. FOR BUDS.—In early spring cut twigs of American Elm, Bass Wood, Cotton Wood, Hickory, Horse Chest-

nut, Locust, Sugar Maple, noting (*a*) *arrangement of leaf scars;* (*b*) *terminal, lateral, stronger and weaker buds;* (*c*) *the position of the lateral buds relative to the leaf scars;* (*d*) *which bear scaly and which naked buds;* (*e*) *all of the well developed terminal buds, and with magnifying glass distinguish of these their position, structure, arrangement of bud scales and true leaves which they enclose; notice how, in each case, the scales are adapted for protection. Cut off the entire blade of Begonia, plant the petiole in damp soil and see how quickly adventitious buds appear in the axils of the veins.* In Butternut, Apple, Hickory, Lilac, etc., *notice the different arrangement of the supernumerary buds.*

4. FOR LEAVES.—(*a*) Study carefully the differences between Hickory *bud scales*, Lily *fleshy bulb scales*, Pitcher-Plant *leaves*, Prickly-Pear, Cactus *large spines*, Barberry *leaves*, Rose *petals*, Maple *leaf.*

(*b*) What organs are represented in Grape *tendrils*, Plum *thorn*, Prickly Pear, Cactus *flattened joints*, Pea *pod.*

(*c*) In the leaves of White Oak, Stramonium, Birch, Hard Maple, House Ivy, Solomon's Seal, Onion, Timothy Grass, Live-for-ever, White Pine, describe the venation and peculiarities of *apex*, *base*, *margin*, *surface*, *texture.*

(*d*) Collect *Compound Leaves* of Ash, Hemp, Common Field Clover, Sweet Clover, Honey-Locust, Meadow-Rue, Pea, and describe the *parts present*, *method of compounding*, *number of leaflets*, *general characteristics*, *Phyllotaxy.* Collect leafy branches Canada Lily, Crab Apple, Elm, Flax, Locust, Milkweed, Sycamore, White Pine and study the *leaf arrangement of each.*

5. PLANT HAIRS.—Collect leafy branches Garden Verbena, Aster, Ivy, Fleabane, Mullein, Hickory, Walnut, Thistle, Common Hazel, Witch Hazel, Shepherdia, Spanish Moss, Polypodium, Raspberry, Blackberry, and with a magnifying lens study the *various shapes of all the hairs*, observing the *purpose of these* in each case.

Recapitulation.

ROOT ......
- 1ST. As TO ORIGIN = 1. Primary. 2. Secondary. (*a*) Single Primary. (*b*) Multiple Primary.
- 2D. As TO APPEARANCE = 1. Fibrous. 2. Fleshy = (*a*) Conical. (*b*) Napiform. (*c*) Fusiform.
- 3D. As TO ANOMALISM = 1. Aerial Roots. 2. Aerial Rootlets. 3. Epiphytes. 4. Parasites. 5. Saprophytes.
- 4TH. As TO DURATION = 1. Annuals. 2. Biennials. 3. Perennials.

STEM ......
- 1. SUPRATERRANEAN = 1. As to consistence. 2. As to size. 3. As to shape. 4. As to duration. 5. As to growth.
  Irregularities = 1. Culm. 2. Caudex. 3. Stolon. 4. Offset. 5. Runner. 6. Tendril. 7. Spine. 8. Thorn. 9. Prickle. 10. Wart.
- 2. SUBTERRANEAN = 1. Rhizome. 2. Tuber. 3. Corm. 4. Bulb. 5. Scaly Bulb. 6. Tunicated Bulb.

BUDS ......
- 1ST. As TO CONTENTS = (*a*) Leaf bud. (*b*) Flower bud. 2D. As TO POSITION = (*a*) Terminal. (*b*) Lateral or Axillary.
- 3D. As TO IRREGULARITIES = (*a*) Adventitious. (*b*) Accessory. 4TH. As TO CONSISTENCE = (*a*) Scaly. (*b*) Naked.

LEAVES { LAMINA, PETIOLE, STIPULES } = { Simple, Compound = { 1. Pinnate, 2. Palmate } } = { 1. As to shape. 2. As to base. 3. As to apex. 4. As to margin. 5. As to surface. 6. As to texture. 7. As to duration. } VENATION = { 1. Net-veined. { 1. Feather-veined. 2. Digitably-veined. } 2. Parallel-veined. { 1. Longitudinal-veined. 2. Lateral-veined. } }

MODIFICATION =
- 1. Foliage Leaves = (*a*) Perfoliate. (*b*) Connate. (*c*) Equitant. (*d*) Nondistinct. (*e*) Phyllodea. (*f*) Falsely Vertical. (*g*) Cladophylla.
- 2. Storage Leaves. 3. Bud Scale Leaves. 4. Spine Leaves. 5. Climbing Leaves. 6. Pitcher Leaves. 7. Fly-trap Leaves.

Stipules, Ocrea, Legule; *Phyllotaxy* = 1. Alternate. 2. Opposite. 3. Whorled.

PLANT HAIRS = { Unicellular, Multicellular } = Normal use = To absorb nourishment. Abnormal use = 1. For protection. 2. For dispersing Seeds and Fruits. 3. For reproduction.

PART II.

MORPHOLOGICAL BOTANY.

CHAPTER XX.

Structural and Morphological Botanies are so dependent upon each other that they are generally treated conjointly under the one head of Organography, a word coined primarily to include both departments. And while conforming in the previous chapters somewhat to popular custom, I have thought it best to devote a separate chapter here to this interesting subdivision, even though it be to some extend at the sacrafice of repetition.

Botanic morphology has two provinces: 1. The one includes the treatment of the *elementary components* of the various parts of the plants, *i. e.*, *plant structure*; 2. The other refers to the *organs themselves*, as to their different forms, varieties, homologies, and metamorphoses, *i. e.*, *the different uses the same kind of organ may assume.*

It is very easy for us to recognize in highly developed plants as thoroughly distinct from each other *roots*, *stems*, *leaves* and *floral parts*, but as we gradually descend the scale of plant life, these all, slowly it is true, lose their identity by going into organs having analogous nature. These differences are noticeable with the naked eye, but when we bring to our assistance the microscope,

we observe that each one of these component parts is made up of myriads of small units, known as *cells*, each enclosed in a membranous sac, often varying in *shape* (round, ovoid, tubular, etc.), also in *size* and *appearance*. It, therefore, must, necessarily go without saying that in describing plants we must not only treat of the *perfected compound organs themselves*, but also of the *elementary organs or units* composing such compounded structures. One important fact, consequently, must not be lost sight of, viz., that just in the proportion that these formative units combine and arrange themselves, just so will the resultant organ vary in consistence and appearance.

It is well, then, for us to begin this subject with the simpler and gradually go to the more complex forms.

I. **Morphology of Vegetable Life.**—Now what are these life forms and what is the nature of the cell arrangement composing some of them?

The simplest plants, *Protococcus* (Red Snow) or *Glœocapsa*, consist of a single spherical or oval membranous sac, called *cell*. The cells of the former separate as soon as formed, while those of the latter are enclosed by a gelatinous capsule for a little while, which, however, soon absorbs water and thereby is dissolved, thus liberating the cells.

Plants of a little higher order, *Oscillatoria*, are each composed of only a single cell, but several of these are joined end to end, forming a many-celled, straight or curved filament. So far in life all multiplication is by cell division.

Plants still higher organized, Mucor or Penicillium, have two kinds of cells, viz., *nutritive* and *reproductive.* The former are elongated, simple or branched filaments lying upon the surface of the food-producing substance, while the latter are developed in globular cavities (sporangia) or necklace-like branches.

Plants still a little higher, Bladder Sea-weed and Mushrooms, have cells combined in leaf-like expansions or solid axes and as special organs of reproduction. These cells are all very similar, so that it is difficult to draw a distinction between the different looking parts of the *Fucus vesiculosus* (Bladder Sea-weed) or the *Agaricus campestris* (Common Mushroom). When cells are so combined as to present no differentiation between *leaf, stem* and *root,* the product is called a *thallus,* and every thallus-producing plant is a *thallophyte* or *thallogen,* which includes Algae, Fungi, Lichens. Inasmuch as the cells of these are all *thin-walled, flexible* and *spherical, oval* or *elongated,* they are called *Cellular Plants,* in contradistinction to the higher *Vascular Plants,* which have prosenchymatous or wood-cells resembling tubular vessels.

Ascending the scale from Thallophytes we come next to *Liverworts.* The lowest form of these, *Marchantia,* have green, flat, thallus-like stem with scale-like appendages on the under surface; *these are the first true leaves.* The higher forms, *Jungermannia,* have the stems and leaves still more highly developed.

We come next to the Mosses. Here *Polytrichum*

has the stems often to contain thick elongated cells resembling *true wood-cells* of higher plants, and this kind of tissue is sometimes prolonged into the leaf, thus forming a mid-rib. In these the *reproductive apparatus* is more complex than anything heretofore encountered. The female element, *oosphere*, is a protoplasmic mass, called *germ* or *embryonic cell*; it is located inside of a flask-shaped, cellular organ, called *Archegonium*. This is fertilized by small spirally-wound filaments, *antherozoids*, which are developed in cells, called *sperm-cells*, formed inside a cellular sac-like structure = *Antheridium*. This fertilization results in fructification. *Liverworts* and *Mosses* have no true roots or vessels.

As we advance to the *Club Mosses*, *Selaginellas*, *Pepperworts*, *Horsetails* and *Ferns*, each become more complex in structure. New vessels appear for the first time, while some stems are thick and high. Some of the *Calamites* allied to *Horsetails* and abundant during the Carboniferous Period, were as tall as our modern trees, while some of our present southern Ferns attain a hight of 30–40 feet. These have at their summit tufts of leaves, *fronds*, which bear on their under surface the organs of reproduction or fructification. These may have roots, but they are invarably small, never becoming large like tap roots. Thus far all plants mentioned have been Flowerless or Cryptogamous, owing to their reproductive organs, *spores*, being small and inconspicuous. The higher plants are called Flowering or Phanerogamous, as they reproduce by

visible seeds. These seeds differ from spores by containing a rudimentary plantlet in the form of an embryo, all of which can easily be dissected out. The spores, on the other hand, are each only a *single cell*, or *two or more united*, having no distinction of parts until it begins developing through vegetation. These consist of one or two coats enclosing granular and other matters, being similar in structure to pollen. In germination these *spores* produce threads, from which the plant may be directly developed, or these threads may produce an intermediary body = *Prothallus*, from which the fruit-bearing frond or stem ultimately springs.

II. Morphology of the Flower.—The various organs of the bloom are but modifications of one common type, *the leaf*. Such a theory first originated with Linnæus and Wolff, but the poet Goethe, in 1790, published his treatise "On the Metamorphoses of Plants," wherein this subject was well ventilated, and since then all botanists recognize the floral organs to be formed upon the same plan as the leaf, *i. e.*, homologous parts, and that their differences are due to special causes connected with the functions which they have severally to perform. Thus *the leaf* is to elaborate plant food, hence, has a structure, color, etc., toward such an end, whereas the *floral parts* are designed for reproduction, therefore have structure, color, etc., best adapted for performing their several functions. It is not quite correct to say that the parts of flowers are metamorphosed leaves, inasmuch as they never have been leaves, but they

are *homologous* parts to leaves. Constructed of the same elements, upon a common plan, follow the same laws and vary in their manner of development not from any original differences in structure, but on account of special, local and predisposing causes. It is true that these different parts may be changed into one another or into true leaves, which solely depends upon the fact that the *cellular papillæ*, from which all these are formed, are capable of being developed in different ways by laws unknown to us. Thus, often in cultivated Roses the floral axis, instead of producing flowers, bears whorls of true leaves, or the axis may occur prolonged beyond the flower or fruit, becoming a true branch, bearing leaves (termed *median prolification*). Now let us take up these parts in the order of their resemblance to ordinary leaves.

1. *The Bracts.* These are evidently closely allied to the leaf in *structure, form, color* and *in one or more buds developing in their axils* (Daisy, Hen and Chickens). Thus, to convince oneself, examine carefully the Foxglove, the Lilac or the Pæony; and here will be found between leaves and bracts all stages of transition, thus proving them to be homologous parts.

2. *The Sepals* are homologous with leaves in *color* and *general characteristics.* Thus we frequently notice a gradual transition between sepals and bracts, while we have just shown that bracts are truly of the leaf type. In the Camellia the transition is so gradual that it is difficult to distinguish where bracts leave off and sepals begin. In Marsh

Mallow and Strawberry the five sepals alternate with five bracts, and these are so difficult to distinguish one from the other, that some call both sets of organs *sepals*. In the Clover, Primrose, Rose, etc., the sepals are often converted into true leaves. Sepals are generally *sessile*, also *entire* except in Dock, Pæony, Rose, etc., where they are incised or toothed, they are *more transitory* than leaves, are composed of spiral vessels, *netted* and *parallel veined*, with *stomata* and *hairs on under surface*.

3. *The Petals* differ in color from bracts, leaves or sepals, but in general structure they all are analogous. Thus in Calycanthus, Magnolia, White Waterlily, etc., where there are several floral whorls, it is almost impossible to say where sepals end and petals begin, in fact, the position alone sometimes affords us a solution. The identity of petals and leaves is shown by the former often being green (Campanula, Cobæa, Ranunculus), and by their being converted sometimes into partial or entire leaves. The structure of petals, like sepals, leaves, etc., is composed of parenchyma, supported by veins formed of spiral vessels; they are mostly netted veined, covered with epidermis and very seldom stomata on under surface. The petals frequently have a stalk-like portion, corresponding to the leaf petiole (Pink, Wallflower). The shape and outline of petals conform to the many variations of foliage leaves.

4. *The Stamens* of all the organs resemble leaves the least, at the same time it is easy enough to trace in both the similarity of parts. Thus we often see

petals becoming gradually transformed into stamens. In the *White Waterlily* (Nymphæa alba) the inner whorl of petals gradually becomes narrower, while the upper extremity of each has at first two little swellings, which further inward are recognizable as true anthers possessing pollen. In cultivating double flowers the number of petals are increased by converting *stamens* into *petals* one to one. Examine a double Rose and we find all kinds of transition between petals and stamens, whereas there are many cases where stamens are transformed into true leaves. In the stamen the thread-like portion, *filament*, is analogous to the *petiole* of the leaf, and the little case or sac, *anther*, corresponds to the *blade* of the leaf. The structure of the *filament* is of spiral vessels surrounded by parenchymatous tissue covered with a thin epidermis having sometimes stomata, colored hairs, etc. (Dark Mullein, Spiderwort); all of which is identical with the petiole composition. The *connective* of the anther is analogous to the mid-rib of the blade, while the two lobes of the anther correspond to the two halves of the blade folded each upon themselves; the outer surface to the epidermis of its lower side, and the septa to the epidermis of the two halves of the upper surface of the blade united and thickened. The *pollen* corresponds to the parenchyma between the epidermis of the upper and lower surfaces of the blade.

5. *The Pistils*, though analogous to leaves, in the normal condition have no transition from stamens owing to the functions of the two being

so opposite and their structure being so different. If, however, we study the *monstrosities* as met with in the Houseleek, Papavers, etc., we will find the gradual changing from stamens to pistils. Sometimes the stamens are changed into carpels and bear ovules = Poppy, Wallflowers, Willows, etc. The Houseleek sometimes has half of its anthers bearing *ovules* and the other half *pollen*. Here are also found between the true Andrœcium and Gynæcium several whorls of bodies intermediate in nature between stamens and pistils. Those *most external* approach nearest to stamens, while those *most internal* resemble closely the pistil. In Buttercups and Roses, both *pistils* and *stamens* become transformed into *petals*, while in cultivated Roses and Double Cherry the *pistils* are often transformed into true *leaves*, there being no distinct ovary, style or stigma. Here the lower portion, representing the blade of the leaf, is analogous to the *ovary*, and the prolonged portion to the *style* and *stigma*. Again, when we examine the very young pistils on the receptacle, they appear as slightly concave bodies, green color just like leaves, gradually they become more concave until the two margins unite, forming the ovary (Flowering Rush). *The ovary* has an analogous structure to the *blade* consisting of parenchyma, vascular bundles of spiral and other vessels, all covered externally by epidermis. The parenchyma inside epithelium is more delicate and corresponds to the upper surface of the blade; the outside epidermis of the ovary corresponds to the lower surface of the blade, and often has stomata,

hairs, etc. Where the margins of the blade meet and unite at the ventral suture, a thickened layer of parenchymatous tissue is developed, giving rise to the *placenta* which is essentially double.

The style is the prolongation of the *mid-rib* or of its apex, the margins having been rolled inward and united. This also consists of parenchyma, traversed by vasculur tissue, has epidermis corresponding with that of the upper surface of the lamina which is continuous with that of the ovary; it is also beset with stomata and hairs. *The stigma* is composed of tissue (*conducting tissue*) analogous to the interior of the style; this is usually elongated into papillæ, and generally without epidermis.

The pistil having thus been proven to be homologous with the leaf, the *fruit*, which is the ripened pistil, is likewise a modified condition of the leaf. The entire floral axis, as before mentioned, sometimes, instead of producing flowers, will bear whorls of true leaves, while a portion may bear flowers and the extended part only leaves, which is another proof of their identity. It is among the cultivated flowers where we can observe so much of the transitional state. When sepal becomes petal, a petal a stamen, a stamen a pistil = *ascending* or *direct metamorphosis*, but when pistil becomes stamen, stamen a petal, or a petal a sepal or any of these into a leaf = *retrograde or descending metamorphosis.*

6. *The Receptacle* appears to be a modification of the andrœcium from the fact of its parts sometimes alternating with the stamens (Gesnera) and again from some portions of it becoming changed into stamens.

PART III.

MICROSCOPICAL STRUCTURAL BOTANY.

(Vegetable Anatomy, or Histology.)

CHAPTER XXI.

So far, we have been treating the various organs, which are not only the component parts of all higher plants, but through whose agency life and growth are attributed and perpetuated.

We plant a seed, see it develop its embryo into a plantlet, and finally into a tree. We accept the truism that "Tall oaks from little acorns grow," and at the same time are, in a measure, helpless in solving the mysteries of such a process. What is all this material that has so enlarged the plantlet, how did it get there and by what means? Of one thing we are certain, that this increase was effected by the plant's own inherent powers. It therefore becomes an extremely interesting subject to study the mechanism by which certain parts are allowed to exercise their innate functions. With the naked eye we can see but little that will help the solution, and it is not until we have the assistance of a Compound Microscope that tissues and their working

processes can be properly investigated. While some instruments magnify several thousand diameters, the one necessary for our work need not be over five hundred diameters, and indeed one with much less power gives frequently ample service.

Let us give a brief description of the instrument, upon which, for the most part, this department of botany depends. There are two kinds: (1) Simple; (2) Compound.

THE SIMPLE MICROSCOPE is nothing more than the ordinary *hand magnifying glass* or *linen tester*, composed of a simple or compound converging lens. These may consist of a single or several lenses arranged with flat surfaces very close to one another, and joined together on a common axis. By the aid of these instruments we see the *object direct*, but in its magnified form.

THE COMPOUND MICROSCOPE is a complex instrument and with it we do not view the *objects direct*, but an *optical image of the objects*, on a very much enlarged scale, is produced, and it is this that we see. Thus, by separating a number of lenses at proper focal distances, so that each one in turn serves to magnify the image of the other, a magnifying power may be attained that is quite remarkable, *i. e.*, from 2500 to 3000 diameters. The parts of a compound microscope may be briefly given, as follows:

1. *The Eye-piece*, which in the line of vision, is the nearest part to the eye, consists of two plano-convex lenses, mounted in a short metal tube; the one closest to the eye = *eye-lens*; the one farthest

=*field-lens*. These eye-pieces are usually known as *A*, *B* or *C*, according to strength.

2. *The Objective*, which in the line of vision, is the farthest part from the eye, consists of a combination of lenses also mounted in a short metallic tube.

3. *The Stand* is all the remaining portion of the instrument.

4. *The Body* is the two telescoping long tubes. The outer tube = *the Sleeve*; the inner = *the Tube*.

5. *Coarse Adjustment*; 6. *Fine Adjustment*; 7. *Stage*; 8. *Spring Clips;* 9. *Diaphragm*; 10. *Mirror*; 11. *Pillar*; 12. *Base*.

In order to become thoroughly familiar with the microscope, a considerable amount of careful work must be done with it. For this a number of accessories have to be provided, such as *tweezers, scissors, needles, camel's hair pencils, sable pencils, glass rods, pipettes, eye droppers, watch glasses, glass tubing, small saucers, slides, brass rings, cover glasses, various test solutions, acids and varnishes, staining fluids, mounting fluids, turn table, colored paints, razors, etc.*

Now, what are these revelations as made by the microscope?

The first thing we notice upon examining vegetable tissue under a moderately high objective is the outstretched net work or its *cellular condition*. All substances so examined seem to be built up of units, molecules, or we call them *cells*, the same as a wall built of bricks. In these units vital force exists and no place else is it to be found. The plant's whole life-energy, therefore, depends upon

the number of such *living cells*; in these alone resides the *power of increasing a thing in size and substance.*

THE CELL NUMBER.—A cubic inch of a vegetable substance may be composed of so many as 130 millions, while the same amount of other tissues may contain much less, and whereas all of these are not alike, there is enough resemblance, that by studying one we have a close idea of all the others.

THE CELL SHAPE.—When normal it is *globular* or *spheroidal.* If much pressure between them, may be *ellipsoidal, egg-shaped, prismatic, polyhedral, elongated*; or, by exuberant growth in several directions, *star-shaped* or *branching.*

THE CELL SIZE.—In soft tissue they range from $\frac{1}{50}$ to $\frac{1}{5000}$ inch in diameter, in more solid structures from $\frac{1}{4}$ to $\frac{1}{40}$ inch in length by $\frac{1}{1500}$ to $\frac{1}{8000}$ inch in diameter. Their average is about $\frac{1}{500}$ inch in diameter, though in *Water-melon flesh, Elder pith* and *Long Staple Cotton wool* they vary from one to two inches in length.

The second thing noticed, by increasing our objective to a $\frac{1}{5}$ or $\frac{1}{10}$, is the cells' peculiar contents. Primarily, all living cells will be found to possess about the same working implements, by age these may become modified, while *size, shape* and *secondary contents* may also be changed. Owing, then, to altering conditions we can divide cells into three classes, and nearly all substances are composed conjointly of these in varying proportions.

1. *Naked or Primordial cells*; those having no *cell wall,* but being simply a *mass of nucleated protoplasm.*

2. *Clothed or Typical cells*; those having, in addition to the vital elements, a pronounced *cell wall*, which wall is only semi-active.

3. *Dead or Inactive cells*; those having only *cell wall*. These in the most of tissue outnumber by far the living cells and once were active, containing living protaplasm, but now only a skeleton is left, which serves to give firmness and rigidity to the plant and facilitates the free passage of water (sap).

THE CELL MAKE-UP.—The majority of cells have a *cell wall*. It is this sort that is typical and mostly concerns us, and of it we will speak in particular.

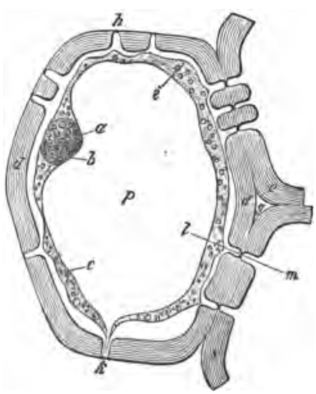


FIG. 48.

Fig. 48 is a section of pith cell of Taxodium. *a* = nucleus; *b* = nucleolus; *c* and *i* = primordial utricle or protoplasm sac, contracted toward the wall, from which it has been separated by reagents (*i* = ectoplasm, *c* = endoplasm), *p* = cellsap in a large vacuole, *l* and *m* = channel between adjacent cells, *d* = cell wall, *e* and *s* = adjacent cell wall, *g* = intercellular space.

If we examine under a high power a section of parenchymatous tissue, as in Fig. 48, we will find that the cells are separated from one another by individual *cell walls* (Fig. 48, *d*, *e*, *s*). This *wall*

consists of two portions separated by the *middle lamella* (Fig. 48, *d*), whose composition slightly differs from, and is more soluble in reagents than the rest of the wall. At the angles of junction we have *intercellular spaces* (Fig. 48, *g*). The space enclosed by this cell wall is partly filled with *protoplasm*, distributed so that an outer layer rests in contact with cell wall. This is tougher and firmer than the rest and constitutes a kind of inner cell wall called *primordial utricle* (Fig. 48, *c* and *i*), which in turn can be differentiated into two layers: an *outer*, Fig. 48, *i* (ectoplasm), having transparency—free from granules, and an *inner*, Fig. 48, *c* (endoplasm), containing minute granules—chlorophyll corpuscles, etc. Located either in the interior or in contact with the endoplasm, is a rounded, granular, more dense and highly refractive piece of protoplasm, called the *nucleus* (Fig. 48, *a*). This is connected with the parietal layer by protoplasmic strands, and these contain also chlorophyll corpuscles, proteid masses, etc. Each *nucleus* has on its interior one or more opaque *nucleolus* or *nucleoli* (Fig. 48, *b*). Chemically this is made up of a proteid, *nucëin*, which has the composition $C_{29}H_{49}N_9P_3O_{22}$. In the process of cell division the nucleus is supposed by many to divide before the protoplasm and to be the centre of the molecular forces of the cell. Others, however, think that the protoplasm is the first to cause cell division and that this, in turn, causes the nucleus to divide, etc. Besides all this we frequently have spaces in the cell, called *vacuoles* or *lacunæ*

(Fig. 48, *p*), which contain a watery fluid (cell sap) having in solution organic and inorganic *wants* and *wastes*. These are chiefly: 1. *Sugars*, as alkaline cupric solutions are reduced, cane-sugar ($C_{12}H_{22}O_{11}$) reduces cupric solution only with long boiling. *Mannite* ($C_6H_{14}O_6$) and *Imulin* ($C_6H_{10}O_5$) do not reduce cupric solution. *Glycogen* ($C_6H_{10}O_5$) dissolves in water with opalescence, but does not reduce cupric solution on boiling. *Glucose* ($C_6H_{12}O_6$)=*dextrose* and *laevulose*, readily reduces cupric solution on boiling. 2. *Organic acids* and *acid salts*, as cell sap reddens litmus paper (malic, tartaric, citric). 3. *Coloring matters*, as here petals derive most of their color (green=chlorophyll, yellow, red, blue). 4. *Crystallizable nitrogenous bodies* (Asparagin, Leucin, Tyrosin). 5. *Inorganic salts* (Nitrates, Chlorides, Sulphates of Potassium and Sodium). 6. *Solid bodies*, often present in vacuoles (Starch grains, Aleurone grains—in seeds, crystals of calcium, carbonate and oxalate). The latter when forming a bundle of acicular crystals = *raphides*. At first, *protoplasm* and *nucleus* fill entire cell cavity, but with age the cell wall, having the protoplasm adherent to it, expands the faster, hence pulls these *lacunae* into existence, all of which may soon run into one of much larger size.

These are truly the *essential* or *primary components* of a *normal cell*, but besides these we invariably have present in the cell other substances of more or less importance, which will be treated of under the head of *non-essential* or *secondary components*.

CHAPTER XXII.

COMPONENTS IN PARTICULAR.

I. Primary Components in Particular.—1. THE CELL WALL.—This is never living matter, but is often permeated with protoplasmic filaments. If we treat this with Iodine solution = yellow color, to this add H_2SO_4 = deep blue color, which proves it to be largely cellulose ($xC_6H_{10}O_5$). The quantity of this increases with age at the sacrifice of the protoplasm. This fact led Schmitz and Strasburger to claim the cell wall to be formed by the actual conversion of a layer of protoplasm, in the *Primordial utricle*, into cellulose. The growth in surface of the *cell wall* may take place either by *intussusception* or by *imbibition* or *stretching*, while in thickness the increase is like that of starch grains, in laminæ, by *apposition*, only in the *former* the deposit is *inward* and in the *latter* it is *outward* = *stratification*, a condition due to the alternation of more with less watery layers. When first formed the cell wall is thin, soft and uniform, but when older it becomes thickened unequally, giving rise to protuberances and peculiar markings on either the outer (separated cells) or the inner (united cells) surface = *striation*. At first the cell wall is *cellulose*, but by age its chemical composition and physical properties receive changes by the in-

filtration of other substances, or by cell wall itself being modified. These changes taking place may be of several kinds:

(*a*) *The formation of the middle lamella*, = a form of lignin.

(*b*) *the formation of suberin*, (cutin) or cork substance.—This forms on outside of the cell wall, and is a protective covering to plants.

(*c*) *The formation of lignin*, or wood substance. —This slightly differs from *suberin* and *cellulose* while both *suberin* and *lignin* molecules contain a larger proportion of carbon than does *cellulose*.

(*d*) *The infiltration of coloring matter*. — In older lignified cell walls, as *heart wood*, (Cherry, Logwood, Mahogany, Red Saunders, Walnut).

(*e*) *The infiltration of mineral matters*.—Silica and Calcium Salts, (carbonate and oxalate), such as found in Acer, Acetabularia, Conifers, Corallina, Cystoliths (Acanthaceæ, Urticaceæ), Diatoms, Fagus, Grasses, Salix.

(*f*) *The conversion into mucilage or gum*.—Here *cell wall* so altered as to be more absorbive of water, and hence, finally it is itself soluble. The composition is still cellulose, but molecular arrangement is altered (Flax, Marshmallow roots, Polemoniums, Quince, various piths and medullary rays).

2. The Protoplasm (Gr. πρῶτος, first + πλάσμα, form).—*Physically*, this exists as a semi-fluid, resembling egg albumen when it is *active*, or we find it almost solid, with little water and apparently *inactive* as seeds, tubers, etc.

Chemically, it is complex, and is constantly changing its molecular structure. It is known to contain C, H, O, N, S, P, so that it may be a combination of several albuminous substances, with admixtures in larger or smaller proportions of water, carbo-hydrates, oils and mineral substances. The granules (metaplasm) forming the endoplasm are but drops of oil, particles of organic and inorganic matter, etc. If we treat a protoplasmic cell with Liquor Potassæ a large portion will be dissolved, leaving a framework which is dissolved in strong KOH. The former is made up of *globulins* and *peptones* (composed of C, H, O, N, S,), the latter is *plastin* (having P in addition).

As the cell ages, the protoplasm consists of little else than plastin—framework ; this is, then, the living protoplasm—*organized proteid* of the cell, whereas the *globulins* are dead—*unorganized* proteid. This is the *aleurone grains* of seeds = a reserve deposit in the meshes of the plastin (framework), these may contain Ca and Mg phosphate (Globoid), Ca oxalate or crystalloids. We also, in higher plants, have protoplasmic bodies, containing coloring matter, called *chlorophyll corpuscles* (Gr. χλωρός, green + φύλλον, leaf), and those containing no coloring matter, called *amyloplasts* (Gr. ἄμυλον, starch + πλαστός, form), starch-forming corpuscles. We also have granules differently colored from *leaf green*, which, to a certain extent, conceals the apparent presence of chlorophyll (Diatoms, Red Marine Algae). These are called *chromoplasts* (Gr. χρῶμα, color + πλαστός,

form). *Crystalloids* are another resting form of protoplasm. They differ from mineral crystals in swelling and loosing their angles with KOH, and in turning yellowish-brown with Iodine.

II. Secondary Components in Particular.

1. CARBO-HYDRATES.—These are complex, consisting of C, H, O, the last two being in the same proportion as the water molecule.

(*a*) *Starch* ($xC_6H_{10}O_5$) is the most important of these, being thus isomeric or polymeric with cellulose. It is produced by the action of *chlorophyll* on *protoplasm* under sunlight. Though its minute granules are at first deposited in the chlorophyll bodies, it soon undergoes solution, and that which is not needed for immediate nutrition and tissues is stored up in various parts of the plant as *reserve food material.* (Roots, tubers, seeds, pith, medullary rays, etc.) These starch grains have a *nucleus* around which, outwardly, successive layers are formed, concentric or eccentric, so that by the shape and striation we can often tell its plant source. Bean = *concentric*; Curcuma, Potato = *eccentric*; Wheat and Maranta. All of these are *simple,* while such as the Oats are *compound* (aggregated in masses.)

(*b*) *Inulin* is isomeric with starch ($C_6H_{10}O_5$) found in Artichoke, Chicory, Dahlia, Dandelion, Elacampane. With Iodine test, however, we have yellow, but with Dil. H_2SO_4 we get glucose. Other carbo-hydrates occur in solution in the cell sap as (*c*) *dextrine,* (*d*) *mucilage,* (*e*) *gum,* (*f*) *sugars.*

2. VEGETABLE ACIDS, such as *malic, oxalic, citric,*

tartaric, acetic, formic, benzoic, cinnamic, gallic, butyric, valerianic, angelic, succinic, succinamic and the *fatty acids*. Some of these are important to the plant, while others are waste products. They are all more or less complex and exist free or as salts.

(*a*) *Malic Acid* ($C_4H_6O_5$) is the common acid of fruits (Apples, etc.).

(*b*) *Oxalic Acid* ($C_2H_2O_4$) is poisonous, but occurs in various plants as salts of K, Na or Ca (Sorrels, etc.).

(*c*) *Citric Acid* ($C_6H_8O_7$) is the acid in Lemons, Limes, Oranges, etc.

(*d*) *Tartaric Acid* ($C_4H_6O_6$) occurs in the various Grapes.

The other acids, while less abundant, have a very wide range of distribution.

3. FIXED OILS OR FATS.—These occur in the cells of various parts of plants, especially in fruits (Olive), seeds, etc. Here they replace starch as a reserve food material, consequently are of importance to plant's life. These = glycerine + fatty acids (oleic, stearic, palmitic, myristic); closely related we have *waxes*, which are fatty acids + complex alcohols other than glycerine. These are non-nutritious, but are protective from *wet, destructive fungi spores* and *excessive evaporation from the plant*. They occur on the epidermis as large or small *excretions* or as *bloom* giving the glaucous appearance. Secretions may be so large as to be a salable product (Wax Myrtle, Wax Palm.)

4. VOLATILE OILS.—These are non-nutritious,

but protect against *insects*, *fungi* and *aid fertilization.*

(*a*) *Hydrocarbons* ($C_{10}H_{16}$,) Turpentine, Cubebs, Lemon.

(*b*) *Oxygenated* = Anise ($C_{10}H_{12}O$), Bergamot, Rose, Sandalwood.

(*d*) *Nitrogenated* = Cherry Laurel, Bitter Almonds ($C_7H_6O. HCN$).

(*e*) *Sulphureted* = Assafœtida, Mustard (C_3H_5 CNS), Horseradish.

Here we have closely related the *camphors* ($C_{10}H_{16}O$), Borneo camphor ($C_{10}H_{18}O$). These are derived from *volatile oils by oxidation.*

5. RESINS, OLEO-RESINS, GUM-RESINS, BALSAMS.—These are excretory products formed by *decomposition* of *tannin* and *other glucosidal bodies.* They are amorphous, transparent, often soluble in alcohol, insoluble in water. If resins mixed with volatile oils = *Oleo-resins* = Venice and Common turpentines. If they contain benzoic or cinnamic acids = *Balsams* (Benzoin, Styrax, Balsams Peru and Tolu). If mixed with gums = *Gum-resins* (Gamboge, Myrrh, Galbanum, Ammoniac). Caoutchouc and Guttapercha are resinous constituents of the milky juice.

6. GLUCOSIDES are found in cell sap in solution or deposited in cell walls. These are compounds which, by the influence of unorganized ferments, such as Ptyalin, Emulsin, Myrosin, etc., are decomposed into glucose and another substance capable of still further decomposition. These contain C, H, O, and a few, N, (Tannin, Salicin, Convolvulin, Arbutin, Daph-

nin, Parillin, Saponin); those containing N = Amygdalin and Laurocerasin. Some are *acid* in reaction, but most are *neutral*. All soluble in water and are active medicines.

7. COMPOUND AMMONIAS (Alkaloids). These are complex bodies derived from proteid matter during *destructive changes* in the living plant. These all contain C, H, N, and many O, and are *Amines* (volatile liquids) or *Amides* (non-volatile solids). They are active principles, mostly used in medicine, and while the fact of being poisonous protects them from the *ravages of animals*, it also sometimes occasions *their own death*. Poppy is poisoned, particularly at or near fruiting, by its Morphine, and to avoid this, to a great extent, nature has assigned Alkaloids mostly to those parts that are less active in growing and which parts, in a reasonable time, are to be *shed* (bark, fruit, seeds). Of these we have two kinds as above mentioned.

(*a*) *Amides*, which contain O, are non-volatile, solid, and may be formed by replacing H in NH_3 with acid radical (Aconitine, Brucine, Caffeine, Quinine, Morphine, Strychnine).

(*b*) *Amines*, which do not contain O, are volatile, liquid, and may be artificially formed by replacing H in NH_3 with alcohol radical (Nicotine, Conine, Sparteine).

AMIDES NOT ALKALOIDAL.—These are not *waste products* or *secretions*, but sustain plant life, and are non-alkaline (asparagin, leucin, glutamin, tyrosin). In the form of *asparagin*, nitrogenous matters are transferred to various parts of the

plant *Reserved proteid* is converted into it, and transferred to the growing parts, where it is again changed into protoplasm, so possibly likewise with the others.

8. UNORGANIZED FERMENTS.—These are nitrogenous compounds having the property of producing chemical changes in substances with which they are in contact; they are similar to the animal ferments ptyalin, pepsin, trypsin. Such as *diastase* and *maltin* convert starch to dextrine and grape sugar. *Emulsin* and *myrosin* decompose glucosides with the formation of grape sugar. *Invertin* (from yeast) converts cane sugar into invert sugar. *Papain* (Paw-paw fruit) converts proteids into peptones.

9. NEUTRAL PRINCIPLES.—These are found in solution in cell sap, such as aloin, quassin, santonin, picrotoxin. They are not well understood, but regarded as waste products of metamorphosed tissue. Sometimes these are regarded as glucosides or non-alkaloidal amides.

10. MINERAL SUBSTANCES.—Cell sap contains many inorganic substances in solution, O, N, CO_2, Si, *salts of* K, Na, Ca, Mg, Fe. The most common are *calcium oxalate*, *calcium carbonate*, *calcium phosphate*, *calcium sulphate* and *silica*. Besides this, crystals of mineral matter are often found in the cell wall and in the interior of the cell.

CHAPTER XXIII.

THE FORMATION OF CELLS AND PLANT TISSUE.

This multiplication of cells, and thereby the increase and enlargement of tissues, can alone be studied through the aid of a microscope, inasmuch as all of these units, their implements, constituents, and processes are on the scale of infinitesmal smallness. When, therefore, we begin the investigation of *tissue development* we soon learn that all *new cells*, to which the enlargement and growth of a plant is due, are formed by three methods, viz.:

1. **Rejuvenescence.**—Here the entire protoplasm of the *old cell* is expelled, when, at once, it surrounds itself with a new wall, thus becoming *another cell.*

2. **Union of Cells.**—Here we have the protoplasm of *two cells* coming together to form *another cell.* This is the reproductive process, and when both cells are *alike* in sex we have *conjugation,* but when the uniting cells are *unlike* in sex we have *fertilization.*

3. **Fission or Division of Cells.**—Here *two or more new cells* are formed from *one* by simple *division, budding* and *granulation.*

PLANT TISSUES.

Such now is the history of the living cell—the basal unit of all organic matter. While no one cell contains at the same time all the substances as heretofore enumerated, yet we do have all the while cells predominating in one or the other, or in several of these constituents. We therefore can have cells specialized for certain places and purposes—an aggregation of which go to make up various kinds of tissues and structure. The lower plants, as already mentioned, consist of a single cell, or a collection of cells, all being similar or alike, but as we take up plants of higher order, we find a variety of tissues—each having individual cells peculiar to itself, and differing more or less from the one described as typical.

We consequently can divide tissue into four classes dependent upon the kinds of composing cells, and these in turn are further subdivided.

I. **Parenchymatous Series** (păr′ĕn-kĭm′a-tŭs).—These cells are nearest like the normal, having the *protoplasm*, *nucleus* and the power of *cell division* up to maturity. Soft cellular tissue, as in pith, green leaves and bark, belongs to this class. Though sometimes *elongated* and *fibrous* they are mostly *cubical*. Of this, we have several varieties, viz:

1. PARENCHYMA (pȧ-rĕn′kĭ-mȧ) (Gr. παρά, beside + ἐν, in + χεῖν, to pour = soft and juicy), as above described.—Here we can have *spongy*, *palisade*, *pitted*, *stellate* and *folded* parenchyma.

2. COLLENCHYMA (Gr. κόλλα, glue + ἔγχυμα, an

infusion) = *angled tissue.*—Here cells are thickened at the angles, and are five or six times longer than broad—*prismatic shape*—occuring in the *epidermis* mainly.

3. SCLEROTIC TISSUE (Gr. σκληρός, hard) = *Stone* or *Grit cells.*—Here cell walls so thick as to have no cavity, and is lignified. Occurs in seed coats, nut shells, pear flesh, Apple and Moonseed pith and Dogbane root.

4. EPIDERMAL TISSUE.—Here we have *one, two* or *three layers of cells,* constituting the outermost covering of the plant.

(*a*) *Stomata* (Gr. ςτόμα–ατος, a mouth) are epidermal cells slightly modified. These occur in *crescent-shaped pairs,* concavities facing each other, so as to leave a small cavity between them. Each cell of the stoma is called a *guard cell.* The opening between the *stoma* enlarges or diminishes, according to outside conditions—light, moisture, etc., thus regulating evaporation.

(*b*) *Water-pores* are also epidermal openings, resembling stomata, but here the guard cells are fixed, and opening is constant in size. Water fills these and not air, and they mostly occur on the *edges* and *upper surfaces,* while stomata are more abundant on *leaf's under side.*

(*c*) *Hairs* are epidermal modifications. These may be of soft parenchyma or hardened by mineral matter deposits (Si, $CaCO_3$), or by wall thickening may become *prickles,* in which case underlying tissue cells contribute strength.

Epidermal cells contain nucleus and white of

egg protoplasm, with or without chlorophyll and hairs, when mature, often containing nothing save air.

(5) **Endodermal Tissue.**—Single compact layer of cells sheathing the fibro-vascular bundles. Cells here long-prisms, four-sided with cutinized walls.

(6) **Suberous Tissue = Cork** is modified parenchyma formed beneath the epidermis *on woody stems, roots and wounded surfaces.* These are *tabular form* in compact radial rows, and at maturity contain only air.

II. **Prosenchymatous Series** (prŏs-ĕn-kĭm′-â tŭs) (Gr. πρός, near, toward + ἔγχυμα, an infusion). —Here the cells at maturity all *lose their nuclei and protoplasm,* and have thickened walls from secondary deposits. Though they may contain starch and proteids they, however, do not assist in nutritive processes and only serve to strengthen or support, hence called "*mechanical tissues.*" They *conduct sap* and are *elongated pointed in shape.* Of this we also have several varieties, viz.:

1. Wood or Libriform Cells.—These make up the woody portion of dicotyledonous stems from pith to bark. They are *compact, elongated, fusiform* and splice each other as the fibers of a twisted rope.

2. Vasiform Cells or Tracheids are between *wood cells and ducts,* and differ from the former in having thinner walls with spiral, pitted, etc., markings, and from the latter by not becoming confluent, by their ends, into tubes. In the case of

Pines these elongated cells possess ***rounded pits***, giving the appearance of one circle within another, and they also often have *septa* stretched across the diametric area, thus dividing cell into *partitions*.

3. DUCTS OR VASCULAR TISSUES.—These are tubes formed from two or more elongated cells. Their width and length are greater than wood cells. When mature they contain no protoplasm, very little cell sap, are unusually filled with air, and have their walls lignified. These, on the inside, are variously marked, and from their kind receive names, thus:

(*a*) *Dotted* or *Pitted*.—These are roundish and scattered over the wall.

(*b*) *Schlariform*.—Pits here much *elongated* transversely, resembling rounds of a ladder.

(*c*) *Spiral*.—The markings are *spiral thickenings*, which sometimes peel off when cell is ruptured.

(*d*) *Annular*.—*Thickenings like rings*. These and the spiral often occur in the same cell and are closely allied.

(*e*) *Reticulated*.—Has the thickenings in form of *network*.

(*f*) *Trabecular*.—Rare and the thickenings *cross the lumen of the cell*.

4. BAST OR LIBER FIBRES (sclereychyma).—Cells very *long*, *taper-pointed*, *thick walls*, *tough and flexible*. Walls are lignified when matured, having oblique, slit-like markings—more refractive and lustrous than wood fibres, also longer and thicker walls; may have transverse septa and mineral crystals. This is the *tough* and *stringy tissue* in liber or

inner bark of Dicotyledons (Basswood, Flax, Hemp, Leatherwood; we also find these in some Monocotyledons and Ferns (Maize, Pumpkin, Tea-plant).

III. **Sieve Series.** — This is the *sieve cells* or *cribriform tissue* found in bast region of fibro-vascular bundles. Cells are *long*, *thin-walled*, *blunt-ended*, having plates with *sieve meshes*. Associated with these are the *companion cells*, which are parenchymatous and rich in albumenoids. These two together form the *soft bast* or *cambiform tissue*. The sieve plates may be on the *sides* or *ends* of the cells (Pumpkin), and these allow complete circulation of nutritive materials from cell to cell, an aggregation of which form long tubes, having these perforated diaphragms thrown cross-wise every now and then. These plates are often very thick from a deposit called *callus*, but rest of cell-wall is very *thin cellulose*.

IV. **Laticiferous Series.**—These contain a *milk* or *latex*, varying in *quantity*, *consistency*, *composition* and *color*, according to its source being most abundant in the parenchyma. We have two kinds of these cells: (1) *Simple*, which are very long and branching (Asclepiads, Euphorbeas), and (2) *Complex*, which are coalesced forming a net work of tubes (Dandelion, etc.). Besides all these tissues we often have in parenchymatous series, cells known according to their specific contents, as *crystal cells*, *resin cells*, *tannin cells*, *oil cells*, *mucilage cells*.

THE PRIMARY MERISTEME consists of the *forming cells* in cambium layer and *growing apices* of

roots, stems, etc. These are all alike, not being old enough to be differentiated into distinct tissues.

INTERCELLULAR SPACES are mostly in *mature tissues*. They may contain simply *air* or *water*, or *crystals*, *milky* or *resinous secretions*, etc. These may be formed by *cell walls splitting* (Arums, Elder pith, Water Lilies, Water Plantains), or by the *rupture* and *destruction* of certain cells (Compositæ, Equisetums, Grasses, Labiatæ, Umbilliferæ, etc.) These are very large in aquatics, and are called *air passages*, serving as buoyants and for respiration.

In order to investigate any of these tissues it is often necessary that they undergo certain preparation.

For parenchymatous series.—May cut very thin sections of pith, soft epidermis, etc., and simply mount in water.

For prosenchymatous series.—May take longitudinal section of Geranium stem, treat it with a hot saturated solution of chlorate potash in nitric acid; rinse with water, tap coverglass to separate cells.

For sieve tissue.—Study longitudinal sections of Pumpkin stem, treat it with alcohol to kill protoplasm; rinse with water, and stain with eosin. The proteids become red and shrunken, so that tubes can be easily traced.

For laticiferous tissue.—Place fresh stems of Euphorbia, Dandelion or Chicory in strong alcohol to coagulate latex and prevent its escape. Make longitudinal sections through the bark, dip into nitric acid, rinse with water, and stain with aqueous solution of methyl green.

CHAPTER XXIV.

TISSUE SYSTEMS AND PLANT GROWTH.

Tissues of Thallophyta—*Unicellular.*—The lowest plant life consists of a single or several soft cells irregularly arranged (Bacteria). These are the smallest objects having vital functions, some sixty thousand being able to lay side by side within the length of an inch. They contain protoplasm and may be *globular, oval, spiral, straight* or *crooked.* They increase prolifically by fission, and swim in animal and plant-fluids from which they obtain nourishment, hence are parasitic or saprophytic. These are known as Schizomycetes (Gr. σχίζω, to divide + μύκης, a fungus). The Yeast Plant is a common example of unicellular organism, it causes fermentation and disintegrates starch grains in flour, thus liberating CO_2 which, struggling to get to the surface, is caught by tough dough, making it thus a porous mass, *or light.*

Multicellular.—Here we have flat cells in masses arranged in two layers forming leaf-like expansions, and from aggregations of like cells we gradually advance to more complex tissues having cells of many kinds and shapes. Such a combination gives us three various systems which enter into the make-up of all plants, be they low or high.

1. The Epidermal.—This includes *epidermis* and appendages of *stomata*, *water-pores*, *hairs* and *glands*, all for protection (Parenchyma).

2. The Fibro-Vascular.—This constitutes the *plant's fibrous frame-work* (Prosenchyma). Gives strength and conducts nutrient fluids. It is mostly composed of *ducts* and *sieve-cells*, and may be enclosed in an *endodermis*.

3. The Fundamental.—This is all that which remains, exclusive of the two previous systems. In lower forms and in herbaceous plants it is abundant, but in woody tissues it occurs sparingly in pulp of leaves, medullary rays, pith, exterior bark layers, collenchyma, cork, sclerotic, lacticiferous and fibrous tissues.

Tissues of Bryophyta.—These are higher than the Thallophyta, consisting often of tissue bundles, mostly mosses with cellular masses, having a semi-vascular-fibro arrangement; some of the fibres approaching the woody character.

Tissues of Pteridophyta.—These are still higher (Ferns, etc.), having a well-defined organization. The outer bark is similar to that of flowering plants, while vascular-woody fibre permeates the stem, and leaf stalks ramify the fronds.

Tissues of Spermaphyta.—These are flowering plants, are the highest organized, and here it may be well to treat of the

HISTOLOGY OF SUCH STEMS AND ROOTS.

Of this class we have two great subdivisions known as: 1. Endogens; 2. Exogens.

1. Endogenous or Monocotyledonous Structure.—Here woody fibres and vessels make up stems and roots of Palms, Maize, Bamboo, Sugar Cane, Grasses, etc. A cross section, Fig. 49, shows a mass of pith, dotted without order all over with bundles of woody fibre, more compacted towards the circumference, the whole inclosed in a circular rind or false bark consisting of smaller and more compacted fibro-vascular bundles.

FIG. 49 is a vertical section of a Palm Stem, showing course and direction of fibres.

Here the hardest wood is outside and the softest inside. There is no concentric arrangement nor well defined differentiation of *pith*, *bark* and *wood*—no silver grain, annual layers nor bark peeling freely from the wood. The rind may be smooth and flinty from silicious deposits. These all mostly inhabit warm climates, though a few exceptions exist, also grow and increase from a central workshop, hence are called *inside growers*.

2. Exogenous or Dicotyledonous Structure.—These are the highest organized plants (Apple, Cherry, Maple, Oak). A cross section, Fig. 50, shows a *central pith* around which concentrically are rings of *wood*, and outside of this rings of *bark*. The central pith is soft parenchyma, and from this thin plates of the same material, called *Medullary*

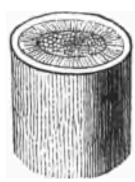


FIG. 50 is a short piece of Flax Stem, magnified, showing the bark, wood and pith in a cross section.

rays, run to the bark, thus separating the *woody bundles*. These medullary rays form the silvery grain of Oak, Maple, etc., so beautiful when smooth and highly polished. These are *outside growers*, and every year a new layer or ring is added to the wood on the outside and a similar new ring of bark on the inside. The zone where all this increase takes place is called the *Cambium layer* (Cambium nutritive juice), situated beteen the wood and the bark. It is right here that all the rich viscid sap circulates, and out of which food material is obtained for abundant new cell production.

THE BARK of exogens has three distinct parts, beginning next to the wood:

1. *The Liber, or Fibrous Bark or Inner Bark.*—This is next to the wood and is composed of *bast* and *sieve*-cells, the former long and tough, serving for cordage and fabrics, the latter form its meshes, giving an interchange of contiguous cell protoplasm.

2. *The Green Bark or Middle Bark.*—This we come to next going from inside to outside, and is all cellular tissue containing chlorophyll.

3. *The Corky Layer or Outside Bark.*—Here cells contain no chlorophyll, but their normal color gives the different outside appearance to various trees—*gray* in Ash; *purple* in Red Maple; *red* in Dogwood. This cork layer may become very thick, as Cork-oak of Spain (Quercus Suber).

4. *The Epidermis or Skin.*—This is the outermost layer of thick sided empty cells.

The green layer grows but little after the first

season, the corky layer often receives yearly accretions inside of the old for a period of years (Cork-oak, Sweet Gum-tree, White and Paper Birch). It finally all dies and the wood inside, continuously growing, causes cracks or fissures. From this and weather exposure the bark is continually peeling off on the outside, but on the inside it is continually being renewed in a faster proportion.

THE WOOD receives a new ring deposit whenever we have a suspension and renewal of growth dependent upon seasons. In cold climates we have one ring added yearly; in more temperate zones we may have more. However, the number of rings will generally serve to accurately tell the tree's age, and some tree stumps have from one to two thousand such rings. The reason that these rings possess different appearances is owing to the varying conditions of the seasons (moist, dry, cold, warm, etc.), and soil (rich, poor, improving, depleting), in which they were respectively produced. This exogenous wood is of two kinds, known respectively as *Sapwood* and *Heartwood.*

(1) *Sap Wood or Alburnum.*—This is the *new wood,* and contains life according to its age, the newest having the most, the older the least, and the oldest having nothing to do with sap circulation, in which state it is converted into heart wood. It is the lightest colored wood, hence called *Lignum album.*

(2) *Heart Wood or Duramen.*—This is harder, more solid, durable and more highly colored than sap wood (Red Cedar, Black Walnut, Ebony).

The change of sap wood into heart wood results from the deposition of hard matter to thicken the walls, and diminish the cell calibre, at the same time infiltrating special vegetable coloring material, giving rise to the name Lignum nigrum. This is not living wood, and hence often decays, weakening simply the tree trunk.

The living parts of a tree are the *rootlets* at one end, the *buds* and *leaves* at the other, and the connecting zone of *cambium*. These parts are all renewed every year, consequently a tree lives indefinitely, always having life to abandon the parts that are *old* in favor of those that are *young*. The tissues of *the root* correspond closely with those of the stem, consequently what is said for one may almost equally apply to the other. Here the diameter increases by additional layers, one for each period of activity. The extremities of the roots and each branch, however, is encased by a layer of older cells, called *root cap*. This is to protect the tender infant cells just behind it, which are increasing and multiplying during the growing period in order to extend the root and rootlets throughout the soil.

HISTOLOGY OF LEAVES.

The leaf is an expansion of the fibrous and green layers of the stem's bark, has no corky layer, but is covered with a transparent skin or epidermis resembling that of the stem. The lamina on the upper side is made up of oblong cells standing endwise and closely compacted, thus leaving no vacant

spaces, while the lower side has cells with their long diameters parallel to the face of the leaf, loosely arranged, thus producing many and wide air chambers.

Chlorophyll is abundant on both sides, but more diluted on under, hence this is paler. The upper face can stand much more sunshine, the lower affords a greater circulation of air, hence facilitates transpiration by being more directly connected with the external air by means of *Stomata* or *Stomates*.

The Epidermis can readily be stripped off from a lily leaf or houseleak, when it is found to be composed of one, two or three layers of empty cells. Through this, into the air chambers or intercellular passages, are openings called *Stomata*. These are always between a pair of thin walled guardian cells; these latter open or close the orifice as the moisture or dryness varies. We have in a square inch of the lower face of the lily leaf about 60,000 stomata and only 3000 on the upper face, consequently some of these are so very large that they can be seen with a good hand lense, while others require a moderately high-power microscope. An apple leaf has 100,000 on its under surface.

PART IV.

PHYSIOLOGICAL BOTANY OR VEGETABLE PHYSIOLOGY.

CHAPTER XXV.

What is Physiology, anywhere and any kind? It is the same, be it applied to the animal or plant kingdoms. The simple act of a person eating a good, square meal involves the physiological processes of *mastication*, *deglutition*, *digestion*, *assimilation*, etc. Each one of these is necessary for the food to fulfill its intended purpose. The many articles of diet are affected differently by the various secretions; thus the saliva, gastric juice, pancreatic juice, bile, etc., each has its specific physiological function to perform. So also when we come to botany, we study under this heading how plants, as a whole, *perform their functions; how they absorb, digest and circulate their food; how they, by using nature's chemical and physical forces, convert inorganic into organic matter, and thereby prepare all animal food, as well as material for self-living, building and reproducing.* All of these processes are active so long as *protoplasm* is present, but when it dies the whole plant resolves its complexity, and returns to the mineral kingdom whence it came.

It must be borne in mind, therefore, that all of the plant's activities are solely due to *protoplasm*.

So long as this lives the plant *builds up tissues* and *repairs its wastes* from that which it absorbs out of the air and soil. This *protoplasm* has six characteristic properties distinguishing it from *dead matter*, and by these it can always be recognized: 1. *Contractility*; 2. *Irritability*; 3. *Respiration*; 4. *Destructive Metabolism* (= protoplasm so changes as to cause complex substances to oxidize into simpler forms or waste products which are of no service to plant life); 5. *Constructive Metabolism* or *Assimilation*; 6. *Reproduction*.

It should be remembered that whether this protoplasm be found in plants or animals it always possesses these six recognizable characters; but the "place where" often presents slight modifications, which is due to the differences of *living habits*.

The Constituents of Plants.—If we dry an *ordinary plant*, we find it to lose in weight about 75 per cent.; if the plant be an *aquatic*, its loss may reach 95 per cent.; or if *wood*, 20 to 30 per cent. This *free water* is not only of the greatest importance as a raw material, but it is a great solvent for all plant food, and when thus dissolved these substances can circulate throughout its entire organization, being then known as *sap*. This nutrient liquid now being able to permeate and ramify every portion of the plant in its course, supplies to various parts whatever they may demand for either *waste repair*, *new tissue formation* or for *storage* against future requirements.

If we now burn the plant we observe given off C, H, N and O in the form of CO_2, H_2O (vapor),

etc., while we have left an ash consisting of K, P, S, Ca, Mg, etc., which varies in amount, according to plant's percentage constituents. Some of these are absolutely *essential,* others are *non-essential* or of minor importance, while others are merely *accidental.*

1. ESSENTIAL for the plant's life are C, O, H, N, S, K, P, Fe, Cl. The first three are important, as they furnish the hydro-carbons, carbohydrates, etc. Besides C, O, H, *protoplasm* must also have N, S and sometimes P.

Potassium seems essential to the formation and circulation of starch.

Phosphorus is not only of service in protoplasmic nuclein and chlorophyll, but as phosphates it promotes cell metabolism, as well as dissolves albuminoid substances, aiding their circulation.

Iron is only essential in chlorophyll-bearing plants, as without it vegetation is bleached.

Chlorine seems necessary to Buckwheat and a few other plants.

2. NON-ESSENTIAL or MINOR are Ca, Mg, Na, Si. If plants are deprived of *calcium* salts, we know not why, but they soon die; these, together with salts of *magnesium,* such as phosphates, sulphates and nitrates, are indirectly important in furnishing S, N and P, which can not be absorbed as such, and these also can so act as to form salts out of injurious free acids generated by the plant itself. *Sodium,* though always present, possibly serves only to replace *Potassium,* and as such is only important. *Silicon,* in the form of silica, is abundant in Dia-

toms, Equiseta, Grasses, etc., but having no physiological importance, only serves to give mechanical strength and protection to organs secreting it.

3. ACCIDENTAL are Al, Mn, Fl, Br, I, Li, Ba, Sr, Cu, Co, Ni, Sn, Zn, etc. Only the first five occur in quantities, the others being very rare and inconsiderable.

All of these substances must enter the plant in its food; now how is this effected?

Food of Plants.—When we place a seed in warm, moist soil, the *dormant protoplasm* of the embryo becomes active, water is absorbed, and the *acid ferments* convert the reserve materials, starch and oils, into soluble forms, as dextrine and sugar, and these are applied to new cell formation. The plantlet increases in size at the expense of this stored food until it is exhausted, and by this time it is sufficiently large and well-developed as to roots, rootlets, root hairs, leaves and stem, to take care of itself and thus become an independent plant. The little roots and rootlets go on absorbing, and the delicate leaves assimilate such absorbed materials. The plant must certainly take in the constituents we find in it, not, however, in such a complex form as embryonic stored food, but none, save possibly O, in an elementary form. All the others are in the shape of inorganic compounds. Thus to enumerate:

Oxygen is taken from the *air*, from *water*, which having permeated the soil, holds it in solution, and from *various salts*.

Carbon is from *carbon dioxide*.

Hydrogen is mostly from *water*.

Nitrogen is from the *air*, *ammonia*, *ammonium salts* and *nitrates*.

Sulphur is from the *sulphates*.

Phosphorus is from the *phosphates*.

Chlorine is from the *chlorides*.

Potassium is from *phosphates*, *chlorides*, *sulphates* and *silicates*.

Sodium is mainly from *chloride*.

Calcium, *magnesium* and *iron* from their respective *sulphates*, *carbonates*, *nitrates* and *phosphates*.

Carbon dioxide is mostly from the *air*; a little is from *water* and the *soil*.

Mineral salts exist in *atmospheric dust* sufficient for epiphytic life, but they are more abundant in the *soil*, whence most vegetation obtains it. Organic matter, though often present in the soil and thus forming CO_2 and other gases, is not absolutely necessary for plant life. Thus if the roots of a Bean be placed in 1000 cc. of water which contains 6 centigrammes of a mixture composed of equal quantities of potassium nitrate, iron phosphate and calcium sulphate, and the leaves exposed to air and sunlight, with a temperature of 80° or 90° F., it will be found to grow as though placed in the ground.

Absorption of Food.—*Carbon dioxide* is taken in by the leaves or other chlorophyll-bearing parts. Leaves also absorb other materials, while young branches, hairs, aerial roots, herbaceous stems may act as absorbing organs. Air plants get all food in this way, while aquatics absorb with their entire plant surface.

Water and *mineral matters* are taken in by the delicate root and root hairs through the processes known as *diffusion* and *osmose.* The *first* is the molecular intermingling of two liquids when carefully poured upon one another in distinct layers. The *second* is where two liquids are separated by a non-porous, thin vegetable or animal membrane which both liquids can wet, in which case they soon become intermingled, the stronger current being toward the denser liquid, and on that side the level of the liquid will rise, though water goes faster towards alcohol and crystalloids towards colloids. The explanation seems to be that although this membrane seems non-porous, it is really a net-work of threads, forming meshes, filled with *hygroscopic water*, which is so firmly ensconced as not to be expelled short of tissue destruction. Such a membrane will admit the passage of any fluid miscible with this *constituent water,* but the denser the liquid the slower the process.

Now these cell walls of roots and root hairs are but similar membranes, separating colloidal solutions on the inside from saline solutions on the outside = sap, between which an interchange takes place, having the stronger current toward the interior of the cell.

The imbibition of liquids through the roots is aided by (1) *Numerous root hairs*; (2) *Contact of root hairs with earthy particles* which are enclosed by a film of water. These, in aggregated masses, form a net-work of capillary tubes, through which water is drawn in proportion as the root hairs absorb it. (3) *The exosmotic liquid* (internal one)

is acid which aids in dissolving mineral matters for plant's absorption. (4) *Protoplasm* of the young and growing root cells has great avidity for water.

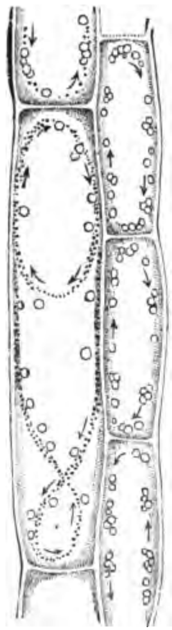


FIG. 51.

Represents a few cells of a leaf of Naias flexilis, highly magnified. The arrows indicate the courses of the circulating currents, and the whole diagram shows how the many cells form capillary tubes through which the sap circulates.

The Ascent of the Sap.—By *diffusion* and *osmose*, then, the sap is passed on from cell to cell till it reaches the *leaves*, etc. The process is greatly aided by *root pressure*, *leaf evaporation*, etc.

Roots continue to absorb, although no room for more, and this forces liquid into other cells beyond = *filtration under pressure.* This phenomenon is due to the outside cell wall having a different mechanical construction from the inside wall, which can give a pressure when measured often of one atmosphere. This *crude sap* circulates upward along the *fibro-vascular bundles*, but in stems of trees mostly in *sap wood* and the *cambium layer*. The descent of the *elaborated sap*, however, is not by these channels, but chiefly by slow diffusion. An equilibrium would soon be reached if diffusion and osmose were all that is concerned in circulation, as all cells would soon have the same composition and constituents. But in the grow-

ing plants there are other disturbing causes, such as, viz.:

(1). Leaf Evaporation.—This enables the leaves to take up more liquid from the cells below, as when surface evaporation takes place a vacuum is produced in the long tubular cells, ducts, etc., which, in turn, is again filled by means of outside *atmospheric pressure*, *diffusion* and *osmose*.

(2). New Cell Formation.—This is constantly going on, and as the protoplasm of each young cell has great avidity for sap it seizes that of its neighbors, and thus breaks up the equilibrium.

(3). Chemical Changes.—These are always going on in the plant. The formation of *new compounds*, the change of densities in substances, of *crystalloids* to *colloids*, *liquids* to *solids* or *vice versa*, all have to be in their new form disseminated throughout the organisms and this disturbs equilibrium. The mechanical movements of leaves, branches, etc., by the wind, animals, etc., may also influence fluid circulation in plants.

(4). Gases in the Plant.—Such as CO_2, O, N and H_2O (vapor), exist either in solution in cell sap, or free in intercellular spaces, and in the cavities of vascular tissues. These gases in living plants are never in an equilibrium state, owing to *constant evaporation* from the surface, to *varying temperature* of the air which causes gaseous expansion and contraction, and to *mechanical movements of plants*. Thus, gases cause trees to bleed in spring time, wherever abraded, which results from the closed condition of the buds, the very few

stomata and other escapes for pent-up gases. This occurs at a season when trees are full of sap, and days hot, causing gases to expand, thus forcing out the sap from the wounds. The maple tree in this way gives us its saccharine sap, which in turn yields *maple sugar*. When temperature falls during the day and always at night, the flow ceases, owing to the gases in the stem contracting, thereby relieving pressure. Later in the summer the flow invariably stops because other avenues are established for the escape and use of the gases: 1, leaves unfolding open up the breathing stomata; 2, temperature becomes less changeable, thus always warm; 3, the protoplasm in the young cells of branches and leaves now absorbs most readily the liquids in the lower portion of the plant. To show the ascent of sap, cut off a leafy branch, put it at once into an aqueous solution of Aniline, Redwood, etc. Several hours thereafter make cross sections at various heights, when will be seen the extent of and the tissues along which it has ascended. Again, cut a leafy stem, run the lower end tightly through a cork that will fit a test tube, nearly fill the tube with water, insert the stem and cork into the tube and expose leaves to sunlight; will soon find the quantity of water to lessen owing to the leaf evaporation.

CHAPTER XXVI.

ASSIMILATION.

Organic beings cannot create energy. Most of them have to get this from the oxidation of complex or simple food materials taken into their bodies, but plants having *chlorophyll* can use the energy of the *sun's rays* in constructing out of inorganic matter these complex organic substances which, in part, they themselves, as well as other plants and animals, use for nutrition and growth. *Chlorophyll*, when receiving the direct *rays of the sun*, goes to acting on *protoplasm*, which in turn produces a *carbohydrate* nearly related to starch. This may combine with N and S as obtained from the various salts absorbed by the plants and then forms *proteid matter*.

We know that all of these are made from water, carbon dioxide and nitrogen in some form, but the precise method is uncertain, and, no doubt, one of much complication. Yet we can approximate this sufficiently to give intelligent possibilities:

$$6CO_2 + 5H_2O = C_6H_{10}O_5 + O_{12},$$
$$10CO_2 + 8H_2O = C_{10}H_{16} + O_{28},$$
$$12CO_2 + 12H_2O = C_{12}H_{22}O_{11} + O_{24},$$
$$10CO_2 + 8H_2O = C_{10}H_{16}O + O_{27}.$$

Leaves are so many *workshops*, each filled with

its own machinery, worked by sun-power. From aquatic leaves oxygen in the state of emission can be collected, or a plant under a globe, supplied with CO_2, will be found, in the sunlight, to lessen this quantity, and to have generated instead, considerable oxygen (compare page 10). On the other hand, animals take in oxygen and give out CO_2, as can be detected when we breathe into lime water. It is by these two converse processes that the animal and vegetable kingdoms are enabled to establish an equilibrium in the constituents of the atmosphere, and thus, in turn to both make it most acceptable and healthy. As a result from these two opposite conditions, it must be remembered that flowers, and plant life in general, are to be avoided in sleeping chambers at night, as it is then that they are simply under the process of *respiration*, *i. e.*, taking in O and giving out CO_2, hence contaminate the confined breathing air, as would additional animal beings. If, however, we slept during the day, having the flowers near us, but in the sunshine, then they would be advantageous to human life, as here *plant assimilation* also goes on. Thus they use up an excessive amount of CO_2 and give out an abundance of free O, thereby purifying the air which we in turn have to breathe.

Materials, how Distributed. — Sap, wherever found, is limpid and transparent, hence all of its constituents are in perfect solution, but *starch* itself is insoluble in cold water and *protoplasm* is colloidal, hence neither of these can diffuse readily, so they have to be converted by ferments into dif-

fusible forms, which they preserve till they circulate the plant and reach their objective points; here they may return to their original or some similar form.

Starch granules, which are formed in the chlorophyll bodies by sunlight, always disappear during the night. This solvent process may go on all the while, both day and night, but its formation is much faster than its solution during the day, hence it may take all night additional for the slower process to catch up to the fast day process. This solution is effected by the aid of an unorganized ferment (diastase, etc.), which consists of converting the starch into *sugar*, all kinds of which being very diffusible may now, as such, go to the growing parts to *construct tissues*, or it may *store itself up* in seeds, tubers, etc., as reserve material (Sugar Beet), or it may pass into and store itself up as either *cellulose* (Ivory Palm, Nux Vomica Seed), or as *fixed oil* (Olive, Flax Seed, Cotton Seed), or it may at first go to form *protoplasm*, *proteid material*, *aleurone grains*, etc. *More frequently it is either reconverted into starch or stored as fixed oil*, and when, as such, the plant demands these again they have to be brought into solution in the form of *sugar* or some soluble carbo-hydrate by a ferment, in order to again admit of their free circulation to growing parts.

Proteids, by the same process, are converted into diffusible *amides*, *asparagin*, *glutamin*, *leucin*, etc.

While some think that *starches* are produced by direct assimilation of CO_2 and H_2O, others con-

tend that they result from *destructive* rather than *constructive* processes. Hence are formed by the breaking down of *protoplasm* and other *proteid matter* through the agency of *chlorophyll*, etc. After being once formed it then turns and acts as a *reconstructor*, be it either in an *active* or *stored-up* condition. All living cells, be they green or otherwise, in darkness or light can produce at least protoplasm out of starch. Chlorophylless plants may grow and increase in darkness (Fungi), while cells of a chlorophyll plant which contain no green coloring matter may equally thrive in light or darkness. *Light is imperative in order to construct organic out of inorganic matter, and that is all.* It is not needed for changes due to oxidation; grains, potatoes, corms, tubers, etc., although chlorophyll plants, often sprout in dark places, and thus continue extending rootlets and caulicles until all reserved starch is consumed. This entire process, however, is attended with no increment in weight; no chlorophyll has been developed; the entire plant is blanched; nothing has been added; the reserved material has only taken new shape and form, and the plantlet will now die unless planted and exposed to *sunlight*, by which power chlorophyll is developed, which in turn acts upon protoplasm, which again, under favorable conditions, constructs *new materials*. Plants can also *reconstruct* living out of dead protoplasm, such as found in decayed organic matter, insects, manures, worms, etc.

Destructive Metabolism.—Construction and *de-*

struction go along at the same time. If the former processes are in excess we have growth; if the latter predominate, then death. The oxidation or disintegration of complex organic structures gives energy to the plant in constructive work. All plants and animals, therefore, have periods of *growth*, *maturity* and *decline*. The products of destructive metabolism are numerous and often complex. They all result from the disintegration of protoplasm or some proteid matter, and consist of *starches*, *fixed oils*, *acids*, *glucosides*, *amides*, *alkaloids*, *resins*, *volatile oils*, etc. *Some* of these are nutritive (starches, carbohydrates, fixed oils, amides), *others* are valuable (acids, which are converted into sugar in many fruits), and *others* aid in dissolving minerals for plant absorption. *Glucosides* may go into sugar = a nutritive carbohydrate, *others* are waste products (alkaloids, resins, volatile oils). These are only of indirect service, being barriers against destructive animals and fungi, while volatile oils may assist cross-fertilization. Although such products are worthless to the plants themselves, they are often of outside importance (alkaloids, etc.). The quantities and qualities of each year's product varies greatly, dependent upon climate, soil, cultivation, altitude, etc., also any abnormal condition of planting may produce harmful rather than harmless products. *Waste products* may be eliminated in parts which the plants annually shed, or as gases, volatile liquids (CO_2, H_2O, volatile oils, etc.), or they may be deposited in cell walls, cuticle, laticiferous tissues, secretion cells, secretion reservoirs, etc.

The temperature at which all plant life flourishes is not uniform. Thus we have arctic and tropic vegetations. The amount of moisture in tissues controls the power of enduring extreme temperatures. Dry seeds, spores, roots, tubers can stand extremes and retain vitality much better than moist ones. Thus the growing plants from these same seeds would perish in a slight frost or in a slightly elevated temperature (120° F.). In the former condition ice crystals are formed in the cells, thus causing protoplasm to be injured and to undergo decomposition in thawing, unless thawed very slowly. In the latter condition the albuminoids are coagulated so as to be unable to absorb water.

PLANT MOVEMENTS.

Nearly all movements are confined to cryptogams owing to the protoplasm of higher plants being confined within rigid and immovable cell walls.

MOVEMENTS, LOCOMOTIVE.—Here we have three kinds:

1. *Amœboid.*—This is the most primitive, and consists of a slow, creeping movement, with form constantly changing, or processes being given out.

2. *Ciliary.*—This is a higher order of movement, as the protoplasm has hair-like projections, *cilia*. The protoplasm is highly contractile and of quick movements (Pandoriva, Volvox, etc.).

3. *Gliding.*—This is the gliding or jerky movements of Diatoms, Desmids, etc., due to excessive protoplasmic contractility.

MOVEMENTS, NON-LOCOMOTIVE:

1. *Protoplasmic movements* within cell wall.—Here the cell contents, as chlorophyll bodies, etc., *in strong light* collect along the side walls of the cell or perpendicularly, while *in dim light* along the outer and inner walls (Nitella, Nettle, Oxalis, Tradescantia).

2. *Geotropism*, jē-ŏt′rō-pĭz′m (Gr. γέα, earth + τρέπειν, to turn).—Gravity in connection with the earth's motion causes movements on the growing organs, thus the roots to grow downward and the stems upward. The former = *positively geotropic*, the latter = *negatively geotropic*, or when transverse to the pull = *transversely geotropic*.

3. *Heliotropism*, hē′lĭ-ŏt′rō-pĭz′m (Gr. ἥλιος, the sun + τρέπειν, to turn).—The light of the sun may cause some plants to turn towards it (positive), while others move away from it (negative). The Sunflower follows the daily course of the sun, and many plants growing in windows bend towards the side of brightest light, having even their leaf blades positioned at right angles to the falling rays. On the other hand, the Ivy, Virginia Creeper, etc., incline away from the light in the endeavor to reach their rootlets towards walls, tree-trunks, etc., so as to climb. The rays of the violet end of the spectrum have most power.

4. *Thermotropism*, thĕr-mŏt′rō-pĭz′m (Gr. θέρμη, heat + τρέπειν, to turn). The deep red spectrum rays attract some organs and repel others.

5. *Hydrotropism*, hī-drŏt′rō-pĭz′m (Gr. ὕδωρ, water + τρέπειν, to turn). Movements made by

young roots and other organs in seeking moist and nutritive soil.

6. *Circumnutation.*—The tips of young shoots, roots, leaves, etc., bow to all points of the compass, thus describing an ellipse. This movement in the case of the radicle aids it in penetrating the soil, while such movements in the upper internodes of twining plants facilitates climbing, by thus bringing the climbing organs in reach of supports by which they raise themselves to light.

7. *Nyctitropic* (Gr. νύξ, νυκτός, night + τροπικός, turning), *or Sleep Movements.*—The leaves of Acacias, Clover, Oxalis, etc., frequently have different positions during the day from night. By day they expand, thus exposing greater surface to light; at night they droop or close, thus preventing heat radiation. Such plants die if this process be interfered with. Some flowers also open in sunshine and close at night., while Evening Primrose, White Lychnis, etc., open at night and close by day.

Many flowers open and, as it were, keep certain hours. The Daisy opens at sunrise and closes at sunset, whence its name "day's-eye." The Dandelion (Leontodon) opens about 7 A. M., closing at 5 P. M.; Arenaria rubra, 9 A. M. to 3 P. M.; White Water Lily (Nymphæa), 7 A. M. to 4 P. M.; Common Mouse-ear, Hawkweed (Hieracium), 8 A.M. to 3 P. M.; Scarlet Pimpernel (Anagallis), 7 A. M. to 3 P. M.; Goats' beard (Tragopogon pratensis), 4 A. M. to 12 M., whence its English name, "John-go-to-bed-at-noon," and farmers in some parts are said to regulate their dinner hour by this

circumstance. Purple Morning Glory opens 2 A. M.; Blue Passion Flower, 12 M.; Evening Primrose, 6 P. M.; Night-Blooming Cereus, 8 P. M. All such movements in flowers have reference mainly to cross-fertilization in some particular, and are the result of some kind of stimulus (gravitation, heat, light, chemical agents, electricity, shock, pressure, contact, etc.). It is claimed that no wind-fertilized flowers sleep, and such flowers that attract insects by smell open and emit their scent at certain hours; thus Hesperus matronalis and Lychis vespertina smell in the evening, while Orchis bifolia is sweetest at night.

8. *Irritability*.—This property is common to all living protoplasm, and all spontaneous movements of plants (Sensitive Plant, Passion Flower, Deonœa, Sarracenia, Barberry, etc.), are due to some kind of a stimulus to this substance. A shock produced by whatever means on this living protoplasm causes it to contract, on a young shoot to bend. All climbing Tendrils and those of Ampelopsis (inclining from strong light) seek supports, shady walls, tree trunks, etc.; if these be reached their sensitive tips are so irritated by this contact as to coil or enlarge into flat disks, which, secreting a cement, connect the plant to these supports; once fastened they continue to climb trees, walls, buildings; otherwise they wither. This sensitiveness is destroyed by anæsthetics. The transference of these sensitive impulses is not by means of nerves, but from cell to cell by shreds of living protoplasm which is continuous in all cells, even through the walls.

PART V.

SYSTEMATIC BOTANY.

CHAPTER XXVII.

SYSTEMATIC BOTANY is that branch of the science relating to the principles upon which plants are to be classified and arranged into groups or ranks according to their *resemblances* or *differences*. In order to prosecute it successfully a complete knowledge of the preceding four divisions of botany is absolutely essential. This systematizing seems truly necessary in order to comprehend the individualities of the manifold species belonging to this great kingdom; it serves, therefore, to give *easiness in method and uniformity in knowledge*.

Some investigators claim there to be 120,000 varying species of plant life, others say 15,0000; others again 200,000, while some go so far as to affirm 250,000 in all; but of these less than 200,000 have received distinctive names. Of this vast number the very few which any of us have studied, each present recognizable differences, and for that reason every solitary one must have a *name*, if it even be only to facilitate reference and communication, because otherwise intelligent expression between men concerning them would be seriously interfered with. From very early times botanists have been engaged in giving definite shape to a

standard nomenclature. This, *for each plant*, consists of two names, the first being called the *genus* and the second the *species*, and may, in a restricted sense, be termed the *binomial system of nomenclature* (*bis*, twice + *nomen*, a name), perfected by Linnæus.

It must be borne in mind that, whenever and wherever these plants from time to time received their *nomen*, the one foremost fact was ever recognized, viz.: *in the original tongue, when primarily named, the names were for the most part so coined as to embody or give reference to some individual property, peculiarity or intrinsic significance which it either did or was supposed to possess.* The etymology or origin of such may frequently be lost or unknown to us, but that does not in any way invalidate the *intent of the unwritten law.* This principle, it must be remembered, not only holds good with the plant life, but equally so in all other scientific departments. It is, therefore, self-evident that before we can place individual names to any plant (or to plants in general) we must investigate at least some of its *distinctive traits and characteristics.* This is only accomplished by taking thousands of plants and studying them together, thus learning by comparison their *affinities*, *habits*, *history*, *properties*, *uses*, and conversely, their superficial as well as deep-seated *variation* and *dissimilarities.* Thus pursued, we will find that all plants are more or less related and form one magnificent system which was planned solely by nature herself through a divine and munificent wisdom. This is called *The Natural System.*

For many years this *innate system* pervading the vegetable kingdom seemed to have been lost sight of, and in its stead were recognized imperfect keys or generalizations, known even at the time of their introduction as *incomplete* and *artificial.* This is called *The Artificial System.* Consequently, between these two botanists have been for a long time vacillating. Now let us take these up and treat them separately at some length.

I. **The Artificial System.**—This system is founded on characters taken from certain parts of plants only, without reference at all to other parts. Of this kind the first one to which prominence was given, and popularity followed, was that of the French physician and botanist (Joseph Pitton de) Tournefort (1656–1708). His classification depended upon the character of the *flowers*, being even restricted in these to the *modification* and *arrangement of the corolla.* He did, however, define and establish the term *genus* as we now understand it; but the rest of his system was in 1736 replaced by one whose author, even to the present day, is regarded as *the father of the science.* This celebrated Swedish botanist, Carolus Linnæus (1707–1778), went a step farther in the right direction than did De Tournefort (deh toor″neh-for′), and introduced improvements by founding the *classes* and *orders on the position, number and relative length of the stamens and pistils.* This sexual system answered very well until, by cultivation and climatic conditions, the flowers were so changed as to be no longer typical—*stamens had become pistils*

and vice versa. No one knew the incompleteness of such a scheme better than did Linnæus himself during his latter days, but nothing more natural could be substituted at that immediate time. It is so different from the one nature has prepared for us, hence called *Natural System,* that it will not be out of place to give its short outline.

ITS GENERA were dependent upon *some single technical character*, having no necessary agreement in any respect, and this frequently brought those next to each other which widely differed in every other respect.

ITS SPECIES of a genus were *always kept together*, whether or not they all accorded with the class or order under which they were placed.

ITS CLASSES, twenty-four in number, were founded upon the *modification of the stamens.* The first eleven had perfect flowers and a definite number of equal and disconnected stamens, and are named from the Greek, viz.:

(1) *Monandria* = one stamen flowers (Hippurus).

(2) *Diandria* = two stamen flowers (Lilac).

(3) *Triandria* = three stamen flowers (Valerian).

(4) *Tetrandria* = four stamen flowers (Scabious).

(5) *Pentandria* = five stamen (most abundant).

(6) *Hexandria* = six stamen flowers (Lily family).

(7) *Heptandria* = seven stamen (Horse Chestnut).

(8) *Octandria* = 8-stamen (Evening Primrose).

(9) *Enneandria* = nine stamen (Rhubarb).

(10) *Decandria* = ten stamen (Rhododendron).

(11) *Dodecandria* = twelve to nineteen stamen flowers (Asarum, Mignonette).

(12) *Icosandria* = flowers perfect with twenty or more stamens (perigynous) (Rose family).

(13) *Polyandria* = flowers perfect with twenty or more stamens (hypogynous) (Anemone, Buttercup).

(14) *Didynamia* = 2 long and 2 short stamens.

(15) *Tetradynamia* = 4 long and 2 short (Cruciferæ).

(16) *Monadelphia* = filaments united in one tube (Mallow family).

(17) *Diadelphia* = filaments united in two tubes.

(18) *Polyadelphia* = filaments united in more than two tubes.

(19) *Syngenesia* = anthers all united in one tube (Composite family).

(20) *Gynandria* = stamens united to the style (Orchis family).

(21) *Monœcia* = stamens and pistils in separate flowers (Oak).

(22) *Diœcia* = stamens and pistils in separate flowers on different individuals (Willow, Poplar).

(23) *Polygamia* = the three kinds of flowers on same plant (Maples).

(24) *Cryptogamia* = stamens and pistils concealed (Ferns, Mosses, Lichens).

Its Orders in the first thirteen classes *depend on the number of styles, or of stigmas, if sessile,* and the names coined from Greek are used metaphorically for pistil:

(1) *Monogynia* = 1 style (embracing all plants of the first 13 classes). (2) *Digynia* = 2 styles.

(3) *Trigynia* = with three styles.

(4) *Tetragynia* = with four styles.

(5) *Pentagynia* = with five styles.

(6) *Hexagynia* = with six styles.

(7) *Heptagynia* = with seven styles.

(8) *Octogynia* = with eight styles.

(9) *Enneagynia* = with nine styles.

(10) *Decagynia* = with ten styles.

(11) *Dodecagynia* = with eleven or twelve styles.

(12) *Polygynia* = with more than twelve styles.

The orders of class (14) *Didynamia*, are two: (1) Gymnospermia, (2) Angiospermia.

The orders of class (15) *Tetradynamia*, are two: (1) Siliculosa = short pod = Silicle; (2) Siliquosa = long pod = Silique.

The orders of (16), (17), (18), (19), (20), (21), (22) classes depend on the number of stamens, *i. e.*, on the characters of the first thirteen classes.

The orders of class (19) *Syngenesia*, are six, viz.:

(1) Polygamia æqualis = flowers perfect in heads.

(2) Polygamia superflua = ray florets are pistillate only.

(3) Polygamia frustranea = ray florets neutral, disks are perfect.

(4) Polygamia necessaria = ray florets pistillate, disks are staminate.

(5) Polygamia segregata = each flower of the head has its own involucre.

(6) Monogamia = solitary flowers with anthers united (Lobelia).

The class (23), *Polygamia*, has three orders: (1) Monœcia, (2) Diœcia, (3) Triœcia.

The class (24), *Cryptogamia* = (1) Filices, (2) Musci, (3) Algae, (4) Fungi.

CHAPTER XXVIII.

II. **The Natural System.**—The Linnæan or Artificial System prevailed until about 1789, when the French botanist, Antoine Laurent Jussieu (zhü''se-uh') (1748–1836), embodying the grand features of John Ray with those of Tournefort, laid the foundation of the *Natural System* which, somewhat modified, has come down to us.

Augustin Pyramus de Candolle (deh kŏn''dol') (1778–1841) greatly modified the arrangement of Jussieu, mainly by *reversing the sequence*, placing the *most highly organized plants first in order.*

This system does not content itself with the stamen and pistil irregularities alone, but takes into consideration everything about plants, thus noticing in detail similarities in *form*, *structure*, *habits of growth* and *functions*, involving the idea of *affinity in essential organs.*

When these are thoroughly understood we can arrange the entire vegetable kingdom into groups of various grades according to their whole make-up, so placing each genus, order, etc., *next to those it most resembles in all respects.* In examining the two hundred thousand varying kinds, all points of agreement as well as difference are noticed, *those sets of characters* which are common to the greatest number of plants are used for the highest or the

primary grand division; those less comprehensive in degree for subordinate groups, etc. Consequently, the character or description of each group, when entirely given, truthfully expresses the main particulars in which the plants it embraces agree among themselves and differ from other groups of the same rank.

KINDS OF CHARACTERS.—No one character or set of characters will serve the purpose. Nor are all characters of equal value in determining the *orders, genus* and *species.*

1. The *numerical plan* of the flower is of much more value than the *shape of the sepals* or *petals.* 2. The *structure of the pistil* has a far greater significance than the *character of the stem* as to its being herbaceous or woody. 3. The *shapes of leaves* distinguish some species, while for others they are perfectly worthless. 4. As a general rule the characters drawn from the *organs of reproduction* (flowers, fruit and seed) are of far more value than those from the *vegetative organs* (root, stem and leaves). 5. Those derived from the *structure* are more important than those from the *habits of the plants.* The structural features of the Elm and the Nettle are analogous, but their habits widely differ, the one being a beautiful forest and cultivated tree, while the other is a pernicious pasture weed.

A classification thus modeled and shaped by man's intuition was but reflected by nature when she first called the vegetable creation into being. It is the plan alone that scientists are now using

their utmost endeavors to perfect by finding every link to the almost endless chain. Mankind itself being imperfect can never expect to ferret out all the mysterious truths that are essential for the completeness of the system, but we are already sufficiently near the goal to accurately know the foundation upon which it was planned and built. Every year new truths are developed that compel us to change our hitherto established facts. Had we, however, from the first every known plant of each genus, no modifications would be necessary. As it is, we may make and ever will make many changes by understanding new plants more fully as to structure and peculiarities. Thus, in 1880 we had Thalictrum anemonoides, it is now Anemonella thalictroides. In 1880, Exogonium purga, now it is Ipomœa purga. 1880 = Leptandra Virginica, now Veronica Virginica. 1880 = Sinapis alba, now Brassica alba, and in the same way Ophelia Chirata becomes Swertia Chirata, Acacia Verek becomes Acacia Senegal, Artanthe elongata becomes Piper augustifolium, and Illicium anisatum becomes Illicium verum. All but the last has had the genus changed, while its change was confined to the species. These modifications may not only affect genera and species, but may extend to orders, etc., and ever will so long as comparative study and investigation is pursued in a conscientious and progressive manner. The relations of the different groups, as far as we are interested, can be represented in the following descending scale:

CLASSIFICATION No. I.

Two Worlds.	Two Kingdoms.	Two Sub-Kingdoms	Four Series or Branches.	Two Classes.	Three Sub Classes. / Two Sub Classes.			
INORGANIC,								
ORGANIC.	ANIMAL,							
	VEGETABLE.	CRYPTOGAMIA =	Thallophyta, Bryophyta, Pteridophyta.					
		PHANEROGAMIA =	Spermaphyta =	Gymnospermæ =	Cycadeæ, Coniferæ, Genetaceæ.	200 Nat. Orders.	9,000 to 10,000 Genera.	150,000 to 200,000 Species.
				Angiospermæ =	Monocotyledons, Dicotyledons.			

CLASSIFICATION No. II.

Sub-Kingdom.	Division.	Class.	Sub-Class.	Series.	Order.	Genus.	Species.
I. CRYPTOGAMIA.							
II. PHANEROGAMIA =	I. Gymnospermæ.						
	II. Angiospermæ =	I. Monocotyledons.					
		II. Dicotyledons =	I. Polypetalæ =	I. Thalamifloræ,			
				II. Disciflorae,			
				III. Calycifloræ.			
			II. Gamopetalæ.				

We have learned the distinguishing features between the two great worlds (inorganic and organic), so have we also between the two kingdoms (animal and vegetable). As early as 1700, John Ray, the English naturalist, separated the vegetable kingdom into two groups or sub-kingdoms: *Cryptogamia* and *Phanerogamia*, and while this division is of much service and stands even to-day as a guide, at the same time we have gone a step farther and made four such *series* or *branches* to replace what was once placed into the two. These four have special characteristics of structure which have heretofore been defined, distinguishing the one from the other. Each series is divided into classes, but only the two belonging to the Phanerogamia are of much interest to us—*Gymnospermæ* (naked seed) and *Angiospermæ* (covered seed). These two in turn are divided into sub-classes, and while the mode of reproduction of the sub-classes to each class are analogous, each of these have a difference in appearance and habits of growth. It is evident that the distinguishing features between all of these higher groups are very wide and marked, in consequence of which these ranks are readily recognized by the average student; again, it is no difficult task ordinarily to differentiate *kingdom* from *kingdom*, *sub-kingdom* from *sub-kingdom*, *series* from *series*, *classes* from *classes*, and *sub-classes* from *sub-classes*; but when we further descend the scale to *orders*, *genera* and *species*, we encounter so many niceties of difference, each and all having their shade of significance, that the

lines of demarcation and distinguishing features become less distinct and numerous, so that accuracy and precision, with our present state of knowledge, is not only often questionable, but sometimes well nigh impossible.

Of the more restricted groups the three known as the *natural order*, *genus* and *species* are of most importance to the pharmacist. It is true that each one of these is subdivided; thus we have under NATURAL ORDER, *sub-orders*, *tribes*, *sub-tribes*; under GENERA we have *sub genera*, *sections*, and under SPECIES we have *varieties*, *races*; but we will confine ourselves to a description of the three most prominent heads.

1. THE ORDERS OR FAMILIES (both words being synonymously used).—These are made up of allied genera, and receive their etymologic names generally by converting the noun name of a leading genus into the adjective form having the termination *æ*, *eæ*, or *aceæ*, which is nominative plural, feminine, agreeing thus with Plantæ understood. Thus Rhamnus = Rhamn-*æ*, *eæ*, *aceæ*; Eric(a) + *æ*, *eæ*, *aceæ*; Euphorbi(a) + *æ*, *eæ*, *aceæ*. The termination *ineæ* seems to be in growing favor at times, giving us, thus, Laur-*ineæ*, Scrophular-*ineæ*, Celostr-*ineæ*, etc. *These orders always begin with capitals.* Each order is composed of those *genera* which, though varying in some respects from each other, have the *essential characters alike*.

The source and creative cause of the *ordinal name* is varying, so that several may be given:

1. The most prominent *genus* of the lot serves

most frequently as the basis; thus the Mallow (L. Malv(a)), gives us N. O. *Malvæ*, *Malveæ*, or *Malvaceæ*; the Rose (L. Ros(a)), gives us *Rosæ*, *Roseæ*, or *Rosaceæ*; the little Frog Buttercup (L. Ranuncul(us)) = *Ranunculæ*, *Ranunculeæ*, or *Ranunculaceæ*; the Moonseed (L. Menisperm(um)) = *Menispermæ*, *Menispermeæ*, or *Menispermaceæ*; the Polygal(a) (Gr. πολύς, much + γάλα, milk) = *Polygalæ*, *Polygaleæ*, *Polygalaceæ*; the scrofula-curing Figwort (L. Scrophulari(a)) = *Scrophulariæ*, *Scrophularieæ*, or *Scrophulariaceæ*; the Poppy (L. Papaver) = *Papaveræ*, *Papavereæ*, or *Papaveraceæ*, etc.

2. Some of the orders are named from certain characteristic structural features applying to the whole group of genera as shown somewhere in the *reproductive organs*, thus: Leguminosæ has the fruit of every genus occurring in *legumes* (L. *legumen*); Umbelliferæ = flowers all in *umbels* (L. *umbella* + *ferre*); Compositæ = all flowers are *compound* (L. *compositus*); *Labiatæ* = all corollas are *two-lipped* (L. *labium*); Cupuliferæ = all fruit borne in a *cup* or *burr* (L. *cupula* + *ferre*, to bear); Guttiferæ (L. *gutta*, a drop + *ferre*, to bear) all yield a *juice which exudes in drops*; Coniferæ (L. *conus*, a cone + *ferre*, to bear). Here such genera as Cedars, Cypress, Larches, Pines, Spruces, etc., although obviously distinct, yet all *bear cones*. Cruciferæ (L. *crux* (*cruc*), a cross + *ferre*, to bear), all the flowers have four petals, and these are arranged in the *form of a Maltese cross*, *i. e.*, all at right angles. This order comprises such

genera as the Cabbage, Cress, Mustard, Radish, Wall-flower, etc. These all differ sufficiently in generic characters, but beyond this they resemble each other in having *didynamous stamens*, and *siliquous fruit*, hence these two points determine the order here as did the cones in the Coniferæ.

3. Then, again, some orders are named after celebrated botanists. These invariably have a typical genera, so named, from which noun name the *ordinal* is derived in the regular way. Asclepiadaceæ, Bignoniaceæ, Magnoliaceæ, Euphorbiaceæ, Ternstrœmiaceæ, Lobeliaceæ.

ORDER ARRANGEMENT. — Our present *Natural System* is but the perfected outgrowth of several more or less incomplete natural systems. Thus some authors as Jussieu, Endlicher and Lindley in their natural classification began with the simplest and ended with the most complicated plant forms. On the other hand, others as Ray, De Condolle, Bentham and Hooker and all modern botanists pursue the converse course, proceeding from the highest to the lowest. We now consequently have all the orders arranged in sequence according to floral completeness, the highest, or typical, belonging to the *Ranunculaceæ*. Here every part is present; no adhesions nor striking modifications. Descending from this perfectness, all others are more or less modified, so that we notice in the several orders immediately following characteristic differences, none of much gravity, however, until the *Cruciferæ* are reached. Here the stamens, six, are tetradynamous, two are in-

serted lower down and shorter than the other four. In the *Violaceæ* the corolla becomes irregular and the anthers begin conniving over the pistil. When we reach the *Hypericaceæ* the stamens are united by their filaments into three or more clusters or tubes. The *Malvaceæ* have this union to a greater extent, as all the filaments are into one tube. So far the *ovary is superior*, and only cohesive modifications have been observed. When we reach the *Leguminosæ* we notice that adhesion of parts is taking place, giving us through *Rosaceæ*, *Hamamelidaceæ*, *Cucurbitaceæ*, etc., perigynous flowers, or *ovary partly inferior*, *i. e.*, the corolla and stamens grow from the calyx instead of the receptacle = Calicifloræ. In the *Umbelliferæ*, *Cornaceæ*, etc., through the *Compositæ*, we have greater adhesions, so that flowers are epigynous or *ovary inferior*. At the same time, within this space of orders, we have also another important change appearing with the *Caprifoliaceæ*, namely, that of *gamopetalous corollas*, although there is noticed an occasional exception. This condition includes such orders as *Rubiaceæ*, *Valerianaceæ*, *Compositæ*, *Lobeliaceæ*, *Ericaceæ*, *Oleaceæ*, *Gentianaceæ*, *Convolvulaceæ*, *Solanaceæ*, *Scrophulariaceæ*, *Labiatæ*, etc. In these the petals not only cohere, but they are inserted on the receptacle, with stamens epipetalous = Corollifloræ. Proceeding along, we come to the *apetalous division*, where the *corolla* and sometimes even the *calyx* are wanting, including such orders as *Chenopodiaceæ*, *Polygonaceæ*, *Aristolochiaceæ*, *Lauraceæ*, *Euphorbiaceæ*,

Urticaceæ, *Cupuliferæ*, *Salicaceæ*, etc. Here the modifications are so great that flowers are incomplete; unisexual, either monœcious, diœcious, or polygamous. Then comes the *Coniferæ* or Gymnospermous Sub-Class, where the *ovules are naked.* Next in order comes Class II, or Monocotyledons, where we find *Scitamineæ* or *Zingiberaceæ*, *Orchidaceæ*, *Iridaceæ*, *Liliaceæ*, *Graminaceæ*, etc. These are *endogens*, *leaves parallel-veined*, *one seed leaf embryo.* Leaving these, we finally come to the Cryptogamous plants, which bear no flowers at all, have no stamens nor pistils, but have *spores* instead of *seeds*. Here we find *Filices*, *Lycopodiaceæ*, *Fungi*, *Lychens*, *Algæ*. This point has been reached by descending gradually from the highest organized flowering plants to the lowest, and finally into the groups of plants bearing no flowers at all. The *order* is the most important of all the *associations* in botany, and on their accuracy of distinction botanists have bestowed the highest degree of attention.

The Natural Orders of Botany have their analogue in animal life (Zoology). Thus, to illustrate, the order *Ruminantia* (L. *ruminans*, chew the cud) is characterized by all of its *genera* having *four stomachs*) Antelopes, Bos, Camels, Deer, Goats, Musk Deer, Neat Cattle, Sheep). The order *Rodentia* (L. *rodens*, to gnaw) includes those *genera* having animals with *two large incisor teeth in each jaw* distant from the molar teeth. These incisors are their instruments for gnawing or cutting (Beavers, Marmots, Rabbits, Rats, Squirrels, etc.).

CHAPTER XXIX.

THE GENUS AND SPECIES.

We come now to the two lower groups of the system, known respectively as *genera* and *species*. These two, when taken together, constitute the name of the plant, and it is these two combined that give us the *Origin* or *Botanical Source*. This is known as the *binomial plan of nomenclature*, and was first brought prominently into use by Linnæus. The name of the *genus* corresponds with our *family* or *surname*, as Brown, Jones, Smith, while the *species* name answers to our *baptismal name*, James, John, William. The White Oak botanically is Quercus alba, the '*Quercus* is *generic* and *alba* is *specific*. In English language, species name comes first; in Latin, the genus name precedes always the specific, hence the sequence here.

THE GENUS is composed of a collection of species resembling one another in general structure and appearance more than they resemble any other species, although a genus may consist of a single or a very few species. The *genus* characters are exclusively taken from the *reproductive organs*, hence a genus = *a collection of species resembling one another in the structure and general characters of the organs of reproduction.* The Live Oak, Red

Oak, Scratch Oak, White Oak, etc., are all species of the Oak genus (L. *Quercus*), differing from each other in some particulars, but agreeing among themselves in *reproductive processes*, etc. The species of the Crow-foot genus differ in *size* and *color of flowers*, some being white, others yellow; in the *size* and *form of stems*, some being erect, others prostrate; in the *shape of their leaves*, etc., but their *organs of fructification* are all constructed on the same plan, and *pollination* is performed in the same manner, hence they constitute the genus Ranunculus. It is the same with the genus Rosa, composed of Carolina, Rose, Dog Rose, Prairie Rose, Smooth Rose, etc., likewise with the genera Castanea, Cratægus, Fagus, Pyrus, all are composed of species differing constantly in some particulars, but are alike in the *organs of reproduction.*

The genus name is always *a noun*, should invariably *begin with a capital*, and with few exceptions is of Latin origin, or taken from other languages and then Latinized. The names themselves have various origins, viz.: 1. Those plants known to and named by the ancients still retain their antique appellations, although the rationale of these is obscure to us (Corylus, Fagus, Mandragora, Petroselinum, Prunus, Quercus, etc.). With so many plants to name, and new ones coming yearly to our notice, it was thought best not to replace them with newer ones, from the fact that the confusion produced by such a change would be a greater source of evil than that which now exists. Besides, to drop these would deprive us of the original source of our

nomenclature, and this we cannot well afford to do, inasmuch as already our necessities often put us to our wits to coin suitable expressive terms. As a result of this we have: 2. That some of the more recently discovered plants have been given old antique names, when such words were expressive and susceptible of Latin termination (Bambusa, Coffea, Thea, Yucca, etc.). 3. By far the most of these, however, are of modern invention, coined to represent some botanical *character*, *habit*, *medical property*, or other *obvious peculiarity*, fancied or real.

Arenaria Caroliniana (L. *arena*, sand) = for a plant growing in sandy soil.

Crassula profusa (L. *crassus*, thick) = for plants having thick leaves.

Dendrobium Falconeri (Gr. *δένδρον*, a tree + *βίος*, life) = to the epiphytic habit of the plant.

Dentaria diphylla (L. *dens*, *dentis*, tooth) = plants with toothed roots.

Epidendrum ellipticum (Gr. *ἐπί*, upon + *δένδρον*, a a tree) = plants growing upon trees.

Impatiens pallida (L. *im* + *patiens*, restless) = capsules explosively rupture when touched.

Hepatica triloba (Gr. *ἧπαρ*, the liver) = leaves shape of the liver.

Delphinum exaltatum (L. *delphinus*, a dolphin) = flower the shape of the classic dolphin.

Campanula glauca (L. *campanula*, a bell) = corolla bell-shaped.

Lactuca virosa (L. *lac*, milk), juice is milky.

Myosurus minimus (Gr. *μῦς*, a mouse + *οὐρά*, a tail) = the receptacle being that shape.

Exogonium purga (Gr. ἔξω, outside of + γυνή, pistil) = from the stamens projecting outside of or beyond the pistil or corrolla.

Cimicifuga racemosa (L. *cimex*, bug + *fugare*, to drive away) = the Siberian Bugbane being used to keep away such vermin.

Lunaria biennis (L. *luna*, the moon) = from the moon-like pods.

Liriodendron Tulipifera (Gr. Λειρίον, a Lily + δένδρον, a tree) = bearing lily-shaped flowers.

Podophyllum peltatum (Gr. ποδὸς, a foot + φύλλον, a leaf) = leaves resemble duck's foot.

Lithospermum latifolium (Gr. λίθος, stone + σπέρμα, seed) = plant with stony seed.

Sanguinaria Canadensis (L. *sanguis*, blood) = from its blood-like juice.

Xanthorrhiza apiifolia (Gr. ξανθός, yellow + ῥίζα, root) = plants having yellow roots.

Utricularia inflata (L. *utriculus*, little bladder) = bearing leaves studded with bladders or sacs.

Scrophularia nodosa, var, *Marilandica* (Latin) = plant is a remedy for scrofula.

Serpentaria (L. *serpens*) = plant cures bites of serpents. Now this is reduced to a specific name = *Aristolochia Serpentaria.*

Pulmonaria angustifolia (L. *pulmonarius*) = used in pulmonary diseases.

4. Genera may bear the names of distinguished botanists, which practice originated with the ancients, thus we have as illustrations:

Pæonia = named after Pæon, who used it in medicines; same with the older names, Euphorbia,

Artemisia, Asclepias, and with the more modern, Linnæa (Linnæus), Clatonia (Clayton), Magnolia (Magnol), Bignonia (Bignon), Lobelia (de Lobel), Lonicera (Lonicer), Tournefortia (Tournefort), Jussiæa (Jussieu), Halleria (Haller), Gronovia (Gronovius), Jeffersonia (Jefferson), Sarracenia (Sarrazin), Asagræa (Asa Gray), Smithia (Smith), Hookeria (Hooker), Lindleyana (Lindley). With the genus we have the same analogue in the animal kingdom, thus belonging to the *cat genus*, Felis, we have the following species, Cat (Felis domestica), Wild Cat, Panther, Tiger, Leopard, Lion; and to the *dog genus*, Canis, we have Dogs (Canis familiaris), Jackal, Wolves, Foxes, etc.

THE SPECIES name is also a single word, and is usually an *adjective* or *substantive* used *adjectively*. If it is an adjective, agreement must be made with the *generic name* in case, gender, etc. It should never begin with a capital unless it be derived from an *old generic name reduced*, or from a proper name, such as of *persons*, *countries* or *places*, and in case of the two latter instances many authorities prefer even there that the entire spelling be of small letters.

The species derive the significance of their names, viz.:

1. From the *color*, *proportion*, *shape*, *surface*, *duration*, *division*, etc., of any or all parts of the plant, *especially from the leaves*; that is, *from characters of a superficial nature and without any reference to their internal structure*.

Thus the following Latin adjectives may illustrate

such referred characteristic properties: excelsa, amara, vulgare, decurrens, gummifer, homolophylla, heterophyllum, vera, millefolium, nobilis, latifolium, polyfolium, lanceæfolia, rotundefolium, variegatum, racemosa, glandulosa, glutinosa, parviflora, triphyllum, serrulata, quinquefolia, paniculata, graveolens, elongata, nudecaulis, montana, maritima, marginale, sativa, crenata, serratifolia, longifolia, fragrans, odorata, acaulis, cordifolia, tomentosum, verticellatus, densifolia, ovalis, alba, niger, lutea, tinctoria, flava, ruber, purpurea, rotunda, campestris, magnifolia, pastoris, lanceolata, obtusa, gigantea, angularis, purgans, florida, pedunculata, medica, procumbens, sempervirens, stipulaceæ, pistillata, hirsuta, herbaceum, triloba, discolor, aureus, dulcis, cinerea, communis, secundiflora, triandra, decandra, octandra, elastica, cardinalis, tripetala, vernalis, viridis, punctata, pulchella, brava, robusta, venenosum, domestica, elliptica, aromatica, centifolia, fusiformis, trivialis, fragilis, erecta, perfoliatum, elegans, gigantum, ponderosa.

Species are individuals of a common origin or parentage, capable of reproducing each its kind, though often differing from each other in *size*, *form*, *flower*, *color*, *leaf*, *shape*, etc., hence species = *a succession of individuals which reproduces and perpetuates itself*.

Whenever specific name is a common adjective its spelling is always begun with a small letter, Hyoscyamus niger, Gentiana lutea, Magnolia grandiflora, Magnolia glauca (under side of leaves glaucous or white), Viola tricolor (Corolla three colored), Viola

rotundifolia (round leaved), Viola pedata (pedately parted leaves), Rubus villosus (leaves hairy), Chondodendron tomentosum (leaves matted with hairs).

If specific name is from a personal name it begins with a capital, and if from the country or place it inhabits or was first found, we, in my opinion, should always begin them with capitals, Viola Canadensis (Canadian Violet, where it grows naturally), Claytonia Virginica, Sanguinaria Canadensis, Solanum Carolinense, Linum Virginianum, Silene Pennsylvanica, Cassia Marylandica, Euonymus Americanus, Opuntia Missouriensis, Draba Caroliniana. While some, including Gray, adhere to these rules, believing that making an adjective form of proper names does not degrade them to common words, others, including U. S. P. editions 1880 and 1890, follow the 1867 Paris Code in recommending *small initial letters* to all specific names except:

a. When species name was once a genus name, D. Stramonium, R. Frangula, S. Dulcamara.

b. When species name from name of a person, Aloe Perryi, G. Hanburii, Pilocarpus Sellvanus.

c. When species name is an indeclinable noun, Acacia Senegal, Erythroxylon Coca.

d. When species name is compounded of a noun and adjective, Xanthroxylum Clava-Herculis.

2. The specific name may be a noun. When it is a proper name, so given to commemorate the discoverer or first lucid describer, it is put in the *genitive case*, Viola Muhlenbergii, Viola Nuttallii, Berberis Fendleri, Conyza Coulteri.

3. When the name is simply complementary,

without the individual's research, the case agrees with genus (nominative) and the adjective form generally used, Carex Torreyana, Carex Hookeriana, Veronica Lindleyana, Amyg. Davidiana.

4. The specific name may be from an old generic name reduced, when it is a noun and then does not necessarily agree with the genus in gender, etc., Magnolia Umbrella, Ranunculus Flammula, Hypericum Sarothra, Linaria Cymbalana, Aristolochia Serpentaria, Piscidia Erythrina, Leptopoda Helenium, Dictamnus Fraxinella, Rhus Cotinus, Rhus Coriaria, Rhamnus Frangula, Dianthus Armeria, Lythrum Salicaria.

Irregularities.—The *specific name* may be a common noun in the genitive case, Polygonum dumetorum (P. of the thickets), Salix desertorum (willow of the desserts), Viola palustris (violet of the marsh).

The specific name may consist of two words—one in the *nominative* the other in the *genitive*, connected by the hyphen — Capsella bursa-pastoris, Carex crus-corvi, Panicum crus-galli, Taraxacum dens-leonis. One of the words may be a noun and the other a qualifying adjective, Ipomœa bona-nox.

It is seldom that specific names are derived from other language than Latin. From Arabic, however, we have Kali in Salsola Kali; and from Greek, Macrocarpon in Vaccinum Macrocarpon, etc.

The species names can be used again and again, but must never occur more than once in any one genus—Digitalis purpurea, Sarracenia purpurea, etc. The same genus name never occurs but the once, so likewise with the natural order.

CLASSIFICATION AND PLANT ANALYSIS.

NOTE.—In order that students may familiarize themselves with the analysis of flowers, I have found it of great advantage to prepare numerous charts similar to the accompanying ones, and give them to the class as weekly exercises. Inasmuch as most college courses are in winter, and only fresh flowers of a few orders can be used in the regular class, nevertheless, a continued practice and thorough drilling in these tables will accomplish surprisingly more than one might imagine. By these one soon observes what are the important points to learn towards classification and the most methodical way by which such can be accomplished. *In taking up a bloom, first write out your skeleton table; then, as the dissection goes on, fill up, as in the remaining tables, according to your observations. When finished, turn to the key in Gray's Manual, 6th edition, page 19, and trace the position of Natural Order and, finally, to the descriptive page of that order, further back in the book, then continuing the search for Genus and Species.*

SKELETON TABLE.

CLASSIFICATION.

Order.................. **Genus**.................. **Species**..................

Date........................ **Locality**............................

Plant..	**Stamens**..................................
Root..	**Anthers**..................................
Stem..	**Filaments**..................................
Leaves..	**Pistil**..................................
Inflorescence..............................	**Stigma**..................................
Flower..	**Style**..................................
Calyx..	**Ovary**..................................
Sepals..	**Seed**..................................
Corolla..	**Fruit**..................................
Petals..	

COMPLETE TABLE No. 1.

Plant.—Perennial, glabrous, herb, not fleshy.

Stem.—Slender, erect, weak and disposed to climb.

Leaves.—Firm, 3-5 lobed, petioled, lobes ovate, lanceolate, coarsely toothed.

Inflorescence.—Racemes.

Flowers.—Regular, blue, helmet erect, obtusely conical, compressed, slightly beaked in front.

Calyx.—Entirely free from pistil.

Sepals.—5, petal-like, very irregular, the upper one (helmet) hooded or helmet-shaped, larger than the others, caducous.

Corolla.—Polypetalous.

Petals.—Diciduous, 2 (the 3 lower wanting entirely, or rudimentary), consisting of small spur-shaped bodies, raised on long claws concealed under the helmet.

Stamens.—Indefinite, rarely few, inserted on receptacle.

Filaments.—Longer than anthers.

Pistil.—3-5, distinct, superior.

Ovules (SEEDS).—Anatropous, with hard albumen.

Ovary.—Closed, containing ovules and seeds.

See page 19, "Gray's Manual." This is in *fives* = Class I (Dicotyledonous). Seeds are enclosed in an ovary = Sub-Class I (Angiospermæ); it is Polypetalous = Division I. Under this head it conforms to large A, No. 1 = *calyx entirely free and separate from the pistil or pistils.* Here we have, at the beginning, four lines commencing each with the word *pistils*, of which the last line suits us best; then we notice the three lines commencing with the word *stamens*, of which the last is the one wanted; then two with *filaments*, two with *flowers*, and the first with *leaves* refers to Ranunculaceæ, page 34, to which we now turn. Read carefully and find Tribe III and four dashes to be Genus No. 18, *Aconitum*, which is more fully described on pages 46 and 47; and No. 2, Species = *uncinatum* (Wild Monkshood).

COMPLETE TABLE No. 2.

Plant.—Low, moist grounds or swampy woods, small tree or shrub, 6-10° high.

Leaves.—Simple, oblong, sharply serrate, 1-2′ long, alternate, stipules free.

Inflorescence.—Drooping racemes, large, glabrous, tomentose.

Flowers.—White, regular, complete, perfect.

Calyx.—5-cleft, thick and fleshy in fruit, adherent to ovary.

Sepals.—Triangular, lance-form, lobes downy within.

Corolla.—Polypetalous.

Petals.—Oblong, elongated, 3-4″ long.

Stamens.—Numerous, short, inserted on calyx.

Style.—5, united below.

Ovary.—5-celled, each cell 2-ovuled, becoming 10-celled in fruit.

Fruit.—On elongated pedicels, globular, purplish, sweet and edible.

Seed.—10, one in each cell of the fruit.

See page 19, "Gray's Manual." At a glance we observe our flower is in *fives*, hence it belongs to Class I = Dicotyledonous. The seeds are in a closed ovary, therefore = Sub-Class I (Angiospermæ); it is *Polypetalous* = Division I. Under this head it conforms to large A, No. 2 = *calyx more or less coherent with the surface of the (compound) ovary.* We find the ovary 5-*celled* and leaves *alternate* (lines

3 and 4), and this refers to Pomeæ in Rosaceæ, page 151, to which now turn. Under Tribe VII, Pomeæ *b*, we read: *cells of the compound ovary becoming twice as many as the styles, each one-celled.* Now turn to page 166, No. 18 = Genus, *Amelanchier* (June Berry); Species, *Canadensis*; Var., oblongifolia; Canada, Virginia.

COMPLETE TABLE No. 3.

Plant.—Perennial herb, arising from a small tuber, moist, open woods, W. and S. United States.

Leaves.—Linear, lanceolate, elongated, 3–6′ long, with one midrib resembling parallel vein.

Inflorescence.—Loose raceme. **Flowers.**—Regular, unsymmetrical.

Calyx.—Persistent, 2-cleft. **Sepals.**—2-ovate, free.

Corolla.—Rose-color, with deeper veins, opening for more than one day.

Petals.—5, hypogynous, polypetalous.

Stamens.—5, adhering to the short claws of the petals, opposite them.

Anthers.—5, versatile.

Style.—Single or united below, 3-cleft at the apex.

Ovary (POD).—1-celled, 3-valved, 3–6 seeded, superior.

See page 19, "Gray's Manual." This is in *fives* = Class I (Dicotyledonous). Seeds are in a closed ovary = Sub-Class I (Angiospermæ); it is Polypetalous = Division I. Under this head it conforms to large B = *stamens of the same number as the petals and opposite them.* Here we find *style* 1, *stigmas* 3, *sepals* 2, *ovules several* (line 6), which refers to Portulacaceæ, page 90, to which now turn. By reading carefully we observe that No. 3 corresponds precisely to the flower thus analyzed = Genus, *Claytonia*; Species, *Virginica* (Spring Beauty).

COMPLETE TABLE No. 4.

Plant.—Herb, perennial.

Root.—Rootstock fleshy and thickened, no runners.

Stem.—Stemless, subterranean.

Leaves.—Alternate with stipules, cordate or reniform, crenate lobed, pubescent.

Inflorescence.—Solitary on scapes.

Flowers.—Violet or purple, axillary, nodding.

Calyx.—Free from the ovary.

Sepals.—5, persistent, extended into ears at the base, auricled.

Corolla.—Spur short and thick, irregular.

Petals.—Somewhat unequal, the lower one spurred at the base, 5, imbricated in the bud.

Stamens.—5, alternate with petals, distinct, closely surrounding the ovary, the two lower bearing spurs.

Filament.—Short and broad. **Anther.**—Adnate, introrse.

Pistil.—1. **Stigma.**—Beaked. **Style.**—1.

Ovary.—1, 1-celled, 3-valved, with 3 parietal placentæ; superior.

See page 19, "Gray's Manual." This is in *fives* = Class I (Dicotyledonous). Seeds are enclosed in an ovary = Sub-Class I (Angiospermæ); it is Polypetalous = Division I. Under this head it conforms to large C = *stamens just the number of the petals, then alternate with them*. Now, No. 1 = *calyx free from ovary*; four stars, two dashes, third line, refers us to Violaceæ, page 78. Here No. 1 is ours = Viola, Violet, Heartsease. Section 1, star 1, dash 2, gives us Genus, *Viola*; Species, *palmata*; Variety, cucullata (Common Blue Violet).

COMPLETE TABLE No. 5.

Plant.—Herb, 4-9′ high, erect, clammy, pubescent, growing on exposed rocks, dry hillsides, perennial.

Root.—Fibrous. **Stem.**—Acaulescent.

Leaves.—Clustered at root, no stipules, obovate or oval, spatulate, narrowed into broad petiole, crenate, toothed, thickish.

Inflorescence.—Clustered cyme, becoming loosely panicled.

Flowers.—On many-flowered scape, perfect.

Calyx.—Nearly free, gamosepalous.

Sepals.—5, cleft or parted, erect. **Corolla.**—Polypetalous.

Petals.—5, entire, imbricated in the bud, commonly diciduous, inserted on calyx, all alike.

Stamens.—10, inserted on calyx.

Pistil.—2. **Style.**—2. **Ovary.**—2, united at base only, axile placentæ.

Pod.—2-celled, 2-beaked follicles.

Seeds.—Numerous, with albumen, close coat.

See page 19, "Gray's Manual." This is in *fives* = Class I (Dicotyledonous. Seed inclosed in an ovary = Sub-Class I (Angiospermæ); it is Polypetalous = Division I. Under this head it conforms to large C = *stamens not more than twice the petals, etc.* Now, No. 2 = *calyx tube somewhat adherent*, and 5th line, page 23, refers us to Saxifragaceæ, page 168, to which refer. Here Tribe I, star 1 and No. 2, gives us the Genus *Saxifraga*; the three stars under this head gives us the Species, No. 6 = *Virginiensis*, Canada, Georgia.

COMPLETE TABLE No. 6.

Plant.—Shrub, or almost herbaceous plant; cool, damp woods in the shade.

Stem.—Slender and extensively creeping on or below the surface.

Leaves.—Alternate, evergreen, obovate or oval, obscurely serrate.

Flowers.—Few, mostly single in the axils, nodding.

Calyx.—5-cleft, in fruit enclosing the small pod, becoming enlarged, and berry-like fruit, free from ovary.

Corolla.—5-toothed, cylindrical, ovoid, regular, gamopetalous, deciduous.

Stamens.—10, free from the corolla, but inserted with it.

Anthers.—2-celled, each 2-awned at the summit, introrse, opening by a terminal pore.

Style.—1. **Ovary.**—5-celled. **Ovules.**—Many, small, anatropous.

Pollen.—Compound, of 4 united grains. **Fruit.**—Loculicidal capsule.

See page 19, "Gray's Manual." This is in *fives* = Class I (Dicotyledonous), also in Sub-Class I; it is Gamopetalous = Division II, and under this head corresponds to large A, to the 6th line, *ovary* 3, *many-celled*, and to the succeeding line, *stamens free, etc.* = Ericaceæ, page 309, to which now refer. We find it under Sub-Order II, Tribe II, stars 2 and dash 1, hence Genus *Gauttheria*, Species *procumbens* Creeping Wintergreen).

COMPLETE TABLE No. 7.

Plant.—Perennial herb, odorous; along brooks.

Stem.—Square.

Leaves.—Ovate-oblong to oblong-lanceolate, acute, sharply serrate, petioled, glabrous.

Inflorescence.—Spikes, leafless, narrow, loose, axillary or spicate.

Flowers.—Pedicellate, whitish purple, nearly 2-lipped and 4-lobed, irregular, crowded clusters.

Calyx.—5-toothed, equal or nearly so, bell-shaped or tubular, persistent.

Corolla.—With a short included tube, the bell-shaped border somewhat equally 4-cleft, the upper lobe broadest, entire or notched.

Stamens.—4, nearly equal, erect, distant, fertile, didynamous, alternate with corolla lobes.

Anthers.—2-celled. **Style.**—2-lobed at the apex.

Ovary.—Deeply 4-lobed, superior. **Seed.**—Solitary, erect.

See page 19, "Gray's Manual." This is in *fives* = Class I, also in Sub-Class I, Division II, No. 2, star 1, line 2 = Labiatæ, page 403, to which now refer. Under Tribe II, stars 2, dash 1 we find Genus *Mentha*, and stars 2 brings us to Species *piperita* (Peppermint).

COMPLETE TABLE No. 8.

Plant.—Perennial, twining, rough, with watery juice, inner bark fibrous.

Stem.—Almost prickly, downward.

Leaves.—Opposite, heart-shaped, palmately 3-5 lobed, with persistent ovate stipules between the petioles.

Bracts.—Smoothish.

Flower.—Diœcious, sterile in loose axillary panicles with 5 sepals and 5 erect stamens; fertile in short axillary and solitary spikes or catkins; bracts foliaceous, imbricated, each 2-flowered, in fruit forming a membranaceous strobile.

Calyx.—Of a single sepal, embracing the ovary.

Sepals.—1. **Petals** —Apetalous.

Stamens.—Opposite the lobes of the corolla. **Anthers.**—Erect.

Filaments.—Short, erect in the bud. **Stigma.**—2, elongated.

Ovary.—1-celled, with a pendulous ovule.

Seed.—With no albumen. **Fruit.**—Achene, glandular, with enlarged scale-like calyx.

See page 19, "Gray's Manual." This belongs to Class I, Sub-Class I, Division III, large B, No. 2, line 7 = Urticaceæ, page 461, to

which refer. Here Tribe III and No. 5 is ours, page 464: thus, Genus, *Humulus*; Species, *Lupulus* (Hop). Alluvial banks, New England, Georgia.

COMPLETE TABLE No. 9.

Plant.—Herb, perennial; rich moist ground.

Root.—A bulb, deep in the ground.

Stem.—Acaulescent or nearly so.

Leaves.—Elliptical-lanceolate, pale green, mottled with purplish and whitish, and commonly minutely dotted; 2, nearly opposite, smooth, shining, flat, tapering into petioles.

Inflorescence. - Solitary.

Flowers.—Light yellow, large, nodding perianth, which is lily-like and apparently of 6 similar components.

Sepals.—Yellow, 3, distinct, lanceolate, spotted at base, recurved.

Petals.—Yellow, 3, callous tooth on each side of base, groove in the middle.

Stamens.—6, one opposite each lobe of the perianth.

Filaments.—6, awl-shaped. **Anthers.**—Oblong linear, introrse, 2 celled.

Style.—1, undivided; club-shaped, elongated.

Ovary.—Obovate, 3-valved, superior, pod loculicidal.

Seeds.—Numerous, with membranaceous tip, obovoid.

Fruit.—Capsule.

See page 28, "Gray's Manual." This flower is in *threes* = Class II (Monocotyledonous), also under large B, as it has *perianth complete*, and this is free, or superior, hence belongs to No. 3, line 9 = Liliaceæ, page 517, to which refer. Here we find it to correspond to Sub-Order II, Series B, stars 2, dashes 2, *Erythronium Americanum*.

COMPLETE TABLE No. 10.

Plant.—Perennial herb, near dwellings. **Stem.**—Square.

Leaves.—Heart-shaped, oblong, deep crenate, whitish, downy underneath, upper floral leaves small, bract-like.

Flowers.—Rather dense, many-flowered, cymose clustered.

Calyx.—Tubular, obliquely five-toothed, more or less curved, 15-nerved, persistent.

Corolla.—Whitish, dilated in throat, 2-lipped, *upper lip* erect, concave, notched, 2-cleft; *lower lip* spreading, 3-cleft, middle lobe largest, 2-lobed or entire.

Stamens.—4, ascending under upper lip, lower pair shorter.

Anthers.—Approximate in pairs. **Style.**—Single, rising from between lobes.

Ovary. — Deeply 4-lobed, free from calyx. **Ovules.** — Solitary. **Fruit.**—Smooth.

THE U. S. PHARMACOPŒIA NATURAL ORDERS, WITH EXPLANATIONS OF DIFFERENCES.

ABBREVIATIONS USED IN THIS CHAPTER.

Cal. = calyx, **Sep.** = sepal, **Cor.** = corolla, **Pet.** = petal, **Sta.** = stamen, **Fil.** = filament, **Anth.** = anther, **Pi.** = pistil, **Ova.** = ovary, **Ovu.** = ovule, **Sty.** = Style, **Stig.** = stigma, **Se.** = seed, **Sup.** = superior, **Inf.** = inferior, **Flos.** = flowers, **Fru.** = fruit, **Alb.** = albumen, **Exalb.** = exalbumen, T. = trees, S. = shrubs, H. = herbs, L. = Latin, Gr. = Greek, **Disting.** = distinguished, **Alt.** = alterative, **Ape.** = aperient, **Anod.** = anodyne, **Anthel.** = anthelmintic, **Ast.** = astringent, **Aro.** = aromatic, **Bit.** = bitter, **Cath.** = cathartic, **Diu.** = diuretic, **Diaph.** = diaphoretic, **Emmen.** = emmenagogue, **Feb.** = febrifuge, **Nar.** = narcotic, **Ton.** = tonic, **Temp.** = Temperate climates, **Trop.** = Tropics, **Sud.** = sudorific, **Poi.** = poisonous, **Demul.** = demulcent.

SERIES I. PHÆNOGAMOUS; CLASS I. DICOTYLEDONS; SUB-CLASS I. ANGIOSPERMÆ.

DIVISION I. POLYPETALOUS.

A. **THALAMIFLORÆ,—Disting.** by flowers having **Cal.**, **Cor.** and **Sta.** distinct from one another; **Ova.**, superior; **Sta.**, hypogynous.

1. RANUNCULACEÆ, rā-nŭn-cū-lā′sē-ē (L. *Ranunculus* + *aceæ*, dim. of *rana*, a frog, hence = little frog, as many species grow in moist places by that reptile), H. or S., with colorless, acrid, poisonous juice. **DISTING.—Flos.**, *most complete, organs all distinct, no adhesion nor cohesion*, often yellow; **Sep.**, 3-15, *mostly* 5; **Pet.**, 3-15, *only one circle*; **Sta.**, *many, inserted on torus*; **Pi.**, *distinct*; **Se.**, Alb., Sup. Temp. Nar., Bit., Ton., Poi. PULSATILLA, STAPHISAGRIA, ACONITUM, CIMICIFUGA, HYDRASTIS.

2. MAGNOLIACEÆ, măg-nō-lĭ-ā′sē-ē (L. *Magnolia* + *aceæ*, after Pierre Magnol, Prof. Botany at Montpellier, France, 1638-1715), T. or S. **Les.**, leathery, stipulate; **Flos.**, *large, sweet-scented, white or red, distinct, except the many pistils cohere*; **Sep.**, 3, *and* **Pet.**, 3-12, *colored alike in* 3 *or more rows of* 3 *each, imbricate*; **Sta.**, *many*; **Fru.**, *cone-like*; **Se.**, Alb., Sup. Temp., Trop. Bit., Ton., Aro. ILLICIUM.

3. MENISPERMACEÆ, mĕn′-ĭ-spĕr-mā′sē-ē (L. *Menispermum* + *aceæ*, Gr. μήνη, the moon + σπέρμα, a seed; fruit is kidney-shaped), S., woody climbers. **Les.**, *exstip.*, *alt.*; **Flos.**, *diœcious*; **Sep.**, 3 **Pet.**, 3, *similar, in* 3 *or more rows of* 3 *each, imbricate*; **Sta.**, *several*, 6 ×; **Fru.**, *drupe, sup.*; *species, heteromorphous, embryo horseshoe-*

shaped, Alb. scanty. Tropic. Bit.. Nar., Ton., Poi. PICROTOXINUM, PAREIRA, CALUMBA, MENISPERMUM.

4. **BERBERID(AC)EÆ**, ber-be-ri-dā'sē-ē (L. *Berber(is)-id* + *eæ* or *aceæ*, fr. *Berbērys*, the Arabic name of the fruit), S. or H. **DISTING.** from allied orders by *the few Sta.* (*same number as Pet. and opp. them*), *in 2 or 3 whorls, and Anth. opening by 2 hinged valves.* Podophyllum = longitudinal, resembles Ranunculaceæ. **Sep.** and **Pet.**, in 2 rows, 3 each, imbricate; **Ova.**, 1-celled, Sup. Temp. Trop. Cath., Ast., Bit., Acrid (Oxalic), Yellow dye. CAULOPHYLLUM, PODOPHYLLUM.

5. **PAPAVERACEÆ**, pā-păv'-ē-rā'sē-ē (L. *papaver* + *aceæ*, poppy, fr. *papa*, pap, or thick milk, formerly used for children, to nourish and cause sleep), H, or S., with milky or colored juice. **DISTING.** *by the 2–3 fugacious Sep. and minute embryo near base of fleshy albumen.* **Flos.**, in 2*s* or 4*s*; **Pet.**, 4-12; **Sta.**, 16 +; **Ova.**, compound, 1-celled; **Anth.**, 2-celled, Sup. Temp. Nar., Emet., Cath., Acrid, Poi. SANGUINARIA, CHELIDONIUM, PAPAVER.

6. **CRUCIFERÆ**, kru-sĭf'e-rē (L. *Crucifer*, fem. pl. fr. *cru(x)c*, a cross + *ferre*, to bear; flowers arranged in shape of Maltese cross), H. or S. **DISTING.** *by pungency or acrid juice, cruciform flos., tetradynamous Sta., and Fru. a silique or silicle.* **Sep.**, 4; **Pet.**, 4; **Sta.**, 6, of which 2 inserted lower down and shorter; **Se.**, Alb., Sup. Temp., Frigid, Trop. Antiscorbutic, Pungent, Acrid (fix. + vol. oils). SINAPIS.

7. **GUTTIFERÆ**, gŭ-tĭf'e-rē (L. fem. pl. *guttifer*, *gutta*, a drop + *ferre*, to bear), T. or S., allied to Hypericaceæ and Malvaceæ, yield resinous juice. **Les.**, coriaceous; **Flos.**, *perfect*; **Sta.**, *many, distinct, mon- or polyadelphous*; **Sep.**, 2–8, often unequal, petaloid; **Pet.**, 2–8 ×; **Ova.**, 1-celled, Sup.; **Fru.**, edible; **Se.**, oily. Trop. Purg., Timber. CAMBOGIA.

8. **TERNSTRŒMIACEÆ**, tėrn-strē-mi-ā'sē-ē (L. *Ternstrœmia* + *aceæ*, after Swedish naturalist Ternström), T. or S. **DISTING.**—**Cal.**, *imbricated in bud*; **Sta.**, *on base of pet., somewhat monadelphous*; **Anth.**, 2-celled, introrse; **Les.**, alt., leathery; **Flos.**, showy, reg.; **Pet.**, 5–6–9; **Ova.**, Sup. Trop. Stim. Ast., Sed.. THEA.

9. **MALVACEÆ**, măl-vā'sē-ē (L. fem. pl. *malvaceus* + *aceæ*, of mallows, *malva*, mallow: Gr. *μαλακός*, soft, mild, owing to its emollient properties or soft, downy leaves), H., S., or T. **DISTING.**—**Sta.**, *monadelphous*; **Anth.**, 1-celled; **Se.**, *reniform*; **Flos.**, reg.; **Sep.**, 5, **Pet.**, 5; **Pi.**, several, united, Alb., Sup. Trop., Temp. Demulcent, Tough fibres. Hairs, as cotton. ALTHÆA, GOSSIPII.

10. **STERCULIACEÆ**, stėr-kū-li-ā'sē-ē (L. *sterculia* + *aceæ*, *stercus*, excrement—*Sterculius* = god of, named from fetid flowers or fruit of certain species), T. or S. **DISTING.** fr. Malvaceæ by **Anth.**, 2-*celled and* **Flos.** *sometimes unisexual by abortion*; **Cal.**, 5; **Cor.**, 5, *twisted.* Trop., Temp. Demul., Emet., Purg. OL. THEOBROMATIS.

B. **DISCIFLORÆ.**—Thalamus with a disk which is hypogynous or adnate to **Cal.** or **Ova.**, or bearing a series of glands; **Sta.** arise from disk either hypog- or perigynous, as many or twice the **Pet.**; **Ova.**, Sup.; placentæ, axile.

11. LIN(AC)EÆ, lī-nā′sē-ē (Classic L. *linum* + *eæ* or *aceæ*, flax; Gr. λίνον), H. **DISTING.—Flos.**, *reg.*; **Sta.**, 5, *monadelphous at base*; **Sep.**, 5, *imbricate*; **Ova.**, 3-5 *celled*, *double the* **Sty.**; **Se.**, 2 *in each cell*, Alb., Sup. Universal, Temp. Demul., Purg., Stim., Sed., Ton., Fibres, Oil. LINUM, COCA,

12. ZYGOPHYLL(AC)EÆ, zū′gō-fi-lā′sē-ē (L. *zygophyll-um* + *eæ* or *aceæ*, Gr. ζυγόν, yoke + φύλλον, leaf, from leaves being bifoliate, yoked and in pairs), H., S. or T. **DISTING.—Flos.**, *white, red, yellow, with fleshy disk*; **Sep.**, 5, *free, glandless*; **Fil.**, 8-10, *have small scales*; **Ova.**, *lobed*, 4-5 *celled*, 2 *filiform ovules in each*; **Pet.**, 4-5, little or no Alb., Sup. Beyond Trop. Stim., Alt., Diaph., Anthel.; Wood, hard, durable. GUAIACI.

13. GERANIACEÆ, jē-rā-nĭ-ā′sē-ē (L. fem. pl. *geraniaceus* fr. *geranium*; Gr. γέρανος, a crane; called Cranesbill from resemblance of the long beak of seed-capsule), H. or S., with stip. and swollen joints. **DISTING.** *from Rutaceæ by* **Les.** *non-glandular, punctate, axis of lobed fruit persistent, carpels distinct, indehiscent.* **Flos.**, *often showy and irreg.*; **Sep.**, 5; **Pet.**, 5; **Sta.**, 10; **Ova.**, lobes as many as **Sep.**, with common **Sty.**, Exalb., Sup. Universal. Ast., Aro., Resinous, Perfumery. GERANIUM.

14. RUTACEÆ, ru-tā′sē-ē (L. fem. pl. *rutaceus*, of or resembling rue, *ruta*; Gr. ῥυτή, ῥύω, to flow, referring to medical properties (female)), T., S. or H. **DISTING.—Les.**, *exstipulate, dotted*; **Sep.**, 3-5; **Pet.**, 3-5, *imbricated*; **Ova.**, *connate or united by either base, Sty. or Stig*; **Sta.**, *distinct, equal or double*; **Pet.**, Alb. or Exalb., Sup. Trop. Antispas., Ton., Feb., Diu. BUCHU, AURANTII, LIMONIS, PILOCARPUS, XANTHOXYLON.

15. SIMARUB(AC)EÆ, sim′-a-ru-bā′sē-ē (L. *Simaruba* + *eæ* or *aceæ*, from native name in Guiana), S. or T. **DISTING.** *from allied Rutaceæ by* **Les.** *exstip., without glands or dots, alt.*; **Ova.**, *stalked, ovules*, 1 *in each cell*; **Sta.**, *augmented each by one or more scales and ovu.*, 1 *in each cell*; **Cal.**, 4-5; **Pet.**, 4-5; **Sta.**. twice, Exalb., Sup. Trop. Bit., Ton., Feb. QUASSIA.

16. BURSERACEÆ, bėr-se-rā′sē-ē (L. *Bursera* + *aceæ*, after Joachim Burser, Ger. botanist, 17th century), T. or S. **DISTING.**—Secrete fragrant gum res. or resinous juice. **Les.**, compound dotted; **Ova.**, *sessile*; **Ovu.**, *in pairs*; **Flos.**, perfect; **Cal.**, 2-5; **Pet.**, 3-5; **Sta.**, twice, Exalb., Sup. Trop. Bit., Purg., Anthel., Poisonous. MYRRHA.

17. CELASTRINEÆ or **ACEÆ**, sel-as-trā′sē-ē (L. *celastr-us* + *ineæ* or *aceæ*, Gr. κήλαστρος, holly; Orig. *celas*, the latter season; fruit remains on tree all winter), T. or S. **DISTING.—Cal.**, *not minute, pod colored, dehiscent*; **Se.**, *in pulpy aril.*; **Ova.**, 2-5 *celled*; **Sep.**, 4-5; **Pet.**, 4-5, *imbricate*; **Sta.**, 4-5, Alb., Sup. Trop. Acrid principle, Oil. EUONYMUS.

18. RHAMNEÆ or **ACEÆ**, răm-nā′sē-ē (L. *rhamn-us* + *eæ* or *aceæ*, Gr. ῥάμνος, the buckthorn, Christ's-thorn, fr. Celtic *ram*, a tuft of branches), T. or S. **DISTING.** *by habit, spiny.* **Sta.**, *perigynous, same number as* **Pet.**, *opp., these involute*; **Sep.**, *valvate*; **Ova.**, 2-4

celled, Sup. or Inf. Universal.—Acrid, Purg., Bit., Feb., Ton.; Dyes; Edible fruits. RHAMNUS PURSHIANA, FRANGULA.

19. SAPINDACEÆ. săp-ĭn-dā'sē-ē (L. *sapindus* + *aceæ*, sap(o) Ind(ic)us, Indian soap, from its saponaceous fruit), T., S. or H., often twining. **DISTING.—Ova.**, 2-5, *united at base only*; **Les.**, *compound*; **Sty.**, 1; **Sep.**, 4-5; **Pet.**, 4-5; **Sta.**, 8-10, *distinct*, *monadelphous*, *disk fleshy*, Exalb., Sup. Trop. Ast., Aro., Diu., Diaph., Ape., Poi. GUARANA.

20. ANACARDIEÆ or **ACEÆ**, an-a-kar-di-ā'sē-ē (L. *anacardium* + *ineæ* or *aceæ*, Gr. ἀνά, alike + καρδία, heart, fruit shape of the heart), T. or S. **DISTING.** by resinous or milky acrid juice. **Ova.**, 1-celled; **Sty.**, 3, *ovule solitary*; **Cor.**, *reg.*, 5-merous, **Fru.**, nutlike drupe, edible, Sup. Trop. Varnishes, Dyes, Poi. RHUS. GLABRA, RHUS. TOXICODENDRON, MASTICHE.

21. POLYGALEÆ or **ACEÆ**, pŏl-ĭ-gā-lā'sē-ē (L. *polygala* + *eæ* or *aceæ*, Gr. πολύς, much + γάλα, milk, thought to increase this secretion), S. or H. **DISTING.—Les.**, *exstip.*; **Flos.**, *irreg.*, *papilionaceous*; **Pet.**, 3-5; **Sta.**, 8, *monadelphous*; **Sep.**, 5, *of which 2 inner = larger*, *wing-like*, *petaloid*; **Ova.**, 2-3 *celled*; **Anth.**, open at top. Has closer affinity, by **Flos.** and **Sta.**, to Violaceæ, Hypericaceæ, as *wings* derived from Cor., but in Polygalaceæ wings fr. *Cal.*; but its keeled flowers allow us to place it near the Leguminosæ. Universal. Bit., Acrid, Ton., Stim., Feb., Emet., Purg., Diu., Sud., Expect., Ast. SENEGA, KRAMERIA.

C. **CALYCIFLORÆ.—Cal.**, usually gamosepalous; **Pet.**, arise from Cal. or from perigynous disk; **Sta.**, perig- or epygynous; **Ova**, Sup. or Inf.

22. LEGUMINOSÆ, lē-gū-mĭ-nō'sē (L. fem. pl. *leguminosus*, pertaining to or bearing legumes; *legumen*, *legere*, to gather; lit., that which may be (easily) gathered), H., S. or T. **DISTING.—Flos.**, *papilionaceous*; **Pi.**, *single*, *which forms into the fruit*, *legume*, *placentæ parietal*, *perigynous*; **Cal.**, 5; **Pet.**, 5; **Sta.**, 10 + mon- or diadelphous. Universal. Cath., Ast., Antispas., Demul., Nutritious; Dyes, Poi., Timber. SCOPARIUS, TRAGACANTHA, GLYCYRRHIZA, PHYSOSTIGMA, KINO, SANTALUM, CHRYSAROBIN, BALSAM PÉRU, BALSAM TOLU, HÆMATOXYLON, CASSIA FISTULA, SENNA, TAMARINDUS, COPAIBA, ACACIA, CATECHU.

23. ROSACEÆ, rō-zā'sē ē (L. fem. pl. *rosaceus*, rose-like; *rosa*, a rose), T., S. or H. **DISTING.** *by prickles*, *warts*, *on woody surface.* **Flos.**, *reg.*, 5*s*, *Sta. inserted on Cal. tube*, *perigynous.* Yellow and white Flos., resemble Ranunculaceæ, but in Rosaceæ Sta. and Pi. are inserted on Cal., in Ranunculaceæ on the torus. Rosaceæ resembles Leguminosæ most, but in that 5th Pet., in this 5th Sep. is nearest the plant's axis. Resembles also Saxifragaceæ, but Rosaceæ has different inflorescence; **Se.**, Exalb.: **Pi.**, many; **Fru.**, often edible. Temp.—Ast., Poisonous. PRUNUM, PRUNUS VIRGINIANA, AMYGDALA, CUSSO, RUBUS, ROSA.

24. HAMAMELACEÆ, **IDEÆ** or **IDACEÆ**, hăm-a-mē-li-dā'sē-ē (L. *hamamel-is* (lid) + *aceæ*, Gr. ἅμα, together with + μηλίς, an apple

tree, name once applied to the Medlar or some similar tree), S. or T. **DISTING.—Ova.**, *inf.*; **Ovu.**, *solitary, pendent from cell-apex*; **Sta.**, 4 *perfect*, 4 *scale-like* (*sterile*); **Flos.**, *heads or spicate, sometimes apetalous*; **Cal.**, 4-5; **Pet.**, 4-5. Temp., Trop. Bit., Ast., Acrid, Balsamic properties. HAMAMELIS, STYRAX.

25. **MYRTACEÆ**, mer-tā'sē-ē (L. *myrtus* + *aceæ*, Gr. μύρτος, myrtle, fr. μύρον, perfume, characteristic of some species), T. or S. **DISTING.—Sta.**, *many*; **Les.**, *exstip.*, *opp.*, *dotted, with marginal vein*; **Cal.**, 4-5; **Pet.**, 4-5; **Sta.**, 8-10×; **Ova.**, Inf., Exalb.; **Fru.**, capsular. Trop., Temperate. Aro, (Oil), Stim., Carm., Diaph., Antispas., Ast., Perfumery, Spices, Edible Fruit, Timber. EUCALYPTUS, PIMENTA, CARYOPHYLLUS.

26. **LYTHRARIEÆ** or **LYTHRACEÆ**, lith-rā-ri'ē-ē (L. *lythrum* + *arieæ*, Gr. λύθρον, gore; so-called from its purple flowers), H. or S., often 4-sided. **DISTING.—Les.**, *exstip.*; **Cal.**, *lobes valvate*; **Pet.**, *wrinkled*; **Ova.**, *sup.*, 2 × celled; **Ovu.**, many; **Sta.**, perigynous, inserted below Pet.; **Fru.**, memb. capsule; **Sty.**, 1 Pod in Cal., 1 cell. Trop., Temp. Ast., Dye. GRANATUM.

27. **CUCURBITACEÆ**, kū-ker-bĭ-tā'sē-ē (L. *cucurbita* + *aceæ*, a gourd, referring to the fruit, fr. *curvitas*, crookedness), H. **DISTING.**—*Succulent, prostrate or climbing with tendrils.* **Flos.**, 5*s*, *unisexual*; **Les.** *and Stem, scabrous*; **Fru.**, *pulpy*; **Ova.**, Inf.; **Fru.**, edible. Trop. Purg. (pulp), Poi. COLOCYNTHIS, ELATERINUM, BRYONIA, PEPO.

28. **UMBELLIFERÆ**, ŭm-bĕl-lĭf'ē-rē (L. *umbellifer*, *umbella*, *umbel* + *ferre*, to bear, referring to the flowers), H. or S. **DISTING.—Flos.**, 5*s*, *in umbels, stems hollow*; **Fru.**, *cremocarp, with oil tubes* (*vittæ*); **Ova.**, *2-celled*, Inf. Temp. Aro., Carmin., Stim., Ton. (vol. oil), Antispas., Nar. (gum resin), Poi. CONIUM, CARUM, ANISUM, FŒNICULUM, CORIANDRUM, SUMBUL, ASAFŒTIDA, AMMOMIACUM.

DIVISION II. GAMOPETALOUS.

29. **CAPRIFOLIACEÆ**, kăp-rĭ-fō'lĭ-ā'sē-ē (L. *caprifolium* + *aceæ*, *caper*, a goat + *folium*, leaf, referring to the climbing and capering plant habit, *like a goat*), T., S. or H. **DISTING.—Les.**, *opp.*, *exstip.*; **Ova.**, Inf.; **Sta.**, 4-5, *on reg. or irreg. Cor. tube*; **Fru.**, *berry or drupe*; **Fil.**, *in pairs at each sinus*; **Anth**, *1-celled.* Temp. Emet., Purg., Ast., Diu., Sodorif., Acrid, Poi. SAMBUCUS, VIBURNUM.

30. **RUBIACEÆ**, ru'-bĭ-ā'sē-ē (L. *rubia*, madder, fr. *rubeus*, red, *rubere*, referring to the color of the roots), T., S. or H. **DISTING.—Stems**, *round or angular*; **Les.**, *opp.*, *stip.*; **Anth.**, *2-celled*; **Ova.**, *inf.*; **Flos.**, 4-5*s*; **Fru.**, edible. Temp., Trop. Ton., Feb., Ast., Emet., Purg., Diu., Emmen., Dye, Tanning, Poi. CINCHONA, CAFFEINA, IPECACUANHA.

31. **VALERIANEÆ** or **ACEÆ**, vă-lē'-rĭ-nā'sē-ē (L. *Valeriana* + *eæ* or *aceæ*, fr. personal name, Valerius, who first used it in medicine, or *valere*, to be strong, or in health, referring to odor or medicinal virtues), H. **DISTING.—Les.**, *opp.*, *exstip.*; **Sta.**, *less*

than Cor. lobes; **Ova.**, 1 *cell perfect*, 2 *empty*; **Ovu.**, 1; **Cor.**, 3–6. Temp. Stim., Antispas., Ton. (vol. oil). VALERIAN.

32. **COMPOSITÆ**, kŏm-pŏz′ĭ-tē (L. *compositus*, pp. of *componere*, put together, compounded, referring to the two kinds of florets (ray and disk) composing each flower-head), H. or S., Largest Order. **DISTING.—Les.**, *exstip.*; **Flos.**, 4-5*s*, *compound heads*, involucre; **Ova.**, *inf.*, 1-*celled*; **Fru.**, *achene*, *Cal. limb forming pappus*; **Sta.**, *syngenesious*. Universal. Ton., Lax., Anthel., Aro., Carmin., Diaph., Stim., Nar. PYRETHRUM, EUPATORIUM, GRINDELIA, INULA, CALENDULA, ANTHEMIS, MATRICARIA, TANACETUM, ABSINTHIUM, SANTONICA, ARNICA, LAPPA, TARAXACUM, LACTUCA.

33. **LOBELIACEÆ**, lō-bē′-lĭ-ā′-sē-ē (L. *Lobelia* + *aceæ*, after Matthias de Lobel, Fleming, botanist and physician to James I, Eng., d. 1616), H. or S. **DISTING.**—Milky juice. **Cor.**, *irreg.*, split to base; spur, none; capsule, 2, valved at summit; **Flos.**, *separate*, *not involucrate*. Allied though differ from Campanulaceæ in Cor. irreg. and Anth. syngenesious, which latter point ally them to Compositæ. Temp., Trop. Emet., Purg., Ves., Nar, Acrid, Poi. LOBELIA.

34. **ERICACEÆ**, ĕr-ĭ-kā′sē ē (L. *erica* + *aceæ*, Gr. ἐρείκη, heath, fr. ἐρείκω, to break, because some species break stone in the bladder), S. or T. **DISTING.—Les.**, *exstip.*; **Cal.**, *inf.*; **Sta.**, free or nearly from the Cor.; **Sty.**, 1; **Ova.**, 3-10 *celled*; **Flos.**, 4-5 *merous*; **Sta.**, *often twice*; **Fru.**, edible. Universal. Ast., Ton., Diu., Nar. Poi. UVA URSI, CHIMAPHILA.

35. **STYRACEÆ**, sti-rā′sē-ē (L. *styrax* + *aceæ*, Gr. στύραξ, the gum storax, an alteration of native Arabic name Assthirak), T. or S. **DISTING.—Cor.**, 5-10; **Sta.**, *equal or twice*, *united at base*; **Ova.**, 2-5 *celled*; **Ovu.**, *at centre or base*; **Cal.**, *coherent with Ova.* Trop., Temp. Stim., Resins, Dyes. BENZOINUM.

36. **OLEACEÆ**, ō-lē-ā′sē-ē (L. *olea* + *aceæ*, Gr. ἐλαία, olive tree; *oleum*, Gr. ἔλαιον, oil, referring to oleaginous fruit), T. or S. **DISTING.—Sta.**, 2; **Ova.**, 2 cells, each with Ovu. 2; **Cor.**, *reg.*, 4*s*. Temp., Trop. Ton., Feb., Purg., Oil, Hard Wood. MANNA.

37. **APOCYNACEÆ**, a-pŏs′-i-nā′sē-ē (L. *apocynum* + *aceæ*, Gr. ἀπό, from, away + κύων, a dog = dog bane, kills dogs), T. or S., milky, acrid. **DISTING.** *from Asclepiadaceæ*, *by Sta. free from Sty. and Stig.*, *also* **Anth.** *contain granular pollen*; **Ova.**, 2, *separate*; **Fil.**, *distinct*; **Flos.**, 5*s*. Trop. Purg., Ton., Feb., Poi. CAOUTCHOUC, APOCYNUM, ASPIDIOSPERMA, STROPHANTHUS.

38. **ASCLEPIADEÆ** or **ACEÆ**, ăs-klē′-pĭ-â-dā′sē-ē (L. *Asclepias(ad)* + *eæ* or *aceæ*, Gr. ἀσκληπιάς, name of Asclepias or Æsculapius, Latin tutelary god of medicine), S. or H., milky, twining, succulent. **DISTING.— Fil.**, *monadelphous*, *pollen in masses on Stig. appendages*; **Fru.**, *pair follicles*; **Flos.**, 5*s*; **Cor.**, *valvate*; **Anth.** and **Stig.**, *peculiar connection.* Trop. Stim., Emet., Purg., Diaph, Antidote to snake bites. ASCLEPIAS.

39. **LOGANIACEÆ**, lō-gā-ni-ā′sē-ē (L. *Logania* + *aceæ*, after J. Logan, a distinguished botanist), S., H. or T. **DISTING.—Les.**, *entire*, *stip. or stipular line*; **Ova.**, 1, Sup., *pod 2-lobed at summit*;

Flos., reg., 4-5 merous. Connection between Gentianaceæ, Apocynaceae, Scrophulariaceæ (from which disting. by *stipules*) and Rubiaceæ, which has *no free ovary*. Trop. Nerv., Ton., Anthel., Poi. NUX VOMICA, GELSEMIUM.

40. GENTIANEÆ or **ACEÆ**, jen-shia-nā'sē-ē (L. *Gentiana* + *eæ* or *acæ*, Gr. γεντιανή, after Gentius (Γέντιος), King of Illyria, who first discovered its properties), H. or S., smooth, bitter. **DISTING.**—**Les.**, *entire, glabrous, sessile*; **Flos.**, *reg.*, 4-10, *capsule 1-celled*; **Se.**, *many*. Universal. Ton., Feb., Stomachic. GENTIANA, CHIRATA.

41. HYDROPHYLLACEÆ, hī-drō-fi-lā'sē-ē (Gr. ὕδωρ, ὑδρ, water + φύλλον, leaf, because each leaf has a cavity for holding water), H. or S., usually hairy, juicy. **DISTING.**—**Les.**, *toothed, lobed, or pinnately compound*; **Flos.**, *scorpioid, reg.*, 5*s*; **Ova.**, 1-celled, 2 parietal placentæ; **Ovu.**, 4; **Sty.**, 2, cleft. Temp. Stim., Ast. ERIODICTYON.

42. CONVOLVULACEÆ, kŏn-vŏl-vū-lā'sē-ē (L. *convolvulus* + *aceæ*, *convolvere*, roll together, entwine, referring to stem's twining habit), H. or S. **DISTING.**—*Twining habit, milky juice.* **Flos.**, 5, *plicate*; **Ova.**, *2-celled*; **Ovu.**, *2 in each cell.* Allied to Solanaceæ and Scrophulariaceæ, but disting *by habit*; alternate leaves, large, solitary seeds with crumpled embryo. Trop., Temp. Purg. (glucosides in juice). JALAPA, SCAMMONIUM.

43. SOLANACEÆ, sŏl-ā-nā'sē-ē (L. *solanum* + *aceæ*, the night shade, fr. *sol*, the sun, or *sulanum*, fr. *sus*, cures swine troubles, or *solor*, to comfort, from its soothing narcotic effects), H. or S., colorless juice. **DISTING.**—**Flos.**, *reg.*, 5*s*, *plicate border*, **Ovu.**, *many*, *embryo straight or coiled in fleshy alb.*; **Fru.**, *capsule or berry*; **Sty.**, 1. Differs from Convolvulaceæ by not twining and having many seeds. Universal, Trop. Nar. Stim., Bit., Ton., Poi. **Fru.** of some edible. CAPSICUM, DULCAMARA, TABACUM, STRAMONIUM, BELLADONNÆ, HYOSCYAMUS.

44. SCROPHULARINEÆ or **ACEÆ**, skrŏf-ū-lā-rī-ā'sē-ē (L. *scrophularia* + *ineæ* or *aceæ*, fr. its efficacy in scrofula), H. or S. **DISTING.**—**Ova.**, *2-celled, central placentæ*, Sup.; **Se.**, *many, in fleshy alb*; **Flos.**, 4-5*s*, *irreg.*, *2-lipped*; **Sta.**, 4, didynamous, or only 2. Universal. Ast., Purg., Emet., Diu., Nar., Poi. Cultivated for beautiful flowers. DIGITALIS, LEPTANDRA.

45. PEDALIACEÆ, pē-dā-li-ā'sē-ē (L. *pedalium* + *aceæ*, *pedalion*; Gr. πηδάλιον, a rudder, named in allusion to the dilated angles of the fruit), H., glandular. **DISTING.**—**Ova.**, sup., 2 carpels becoming 1, 2, 4 or 8-celled; **Fru.**, hard within, around exalb. Se.; **Cal.**, 5; **Cor.**, bilabiate; **Sta.**, didynamous; **Anth.**, 2-celled. Trop. Oily seeds. OL. SESAMI.

46. LABIATÆ, lā-bĭ-ā'tē (L. fem. pl. *labiatus*, lipped, referring to corolla), H. or S. **DISTING.**—*Stems square*; **Cor.**, *irreg.*, *2-lipped*; **Les.**, *opp.*, *aro.*; **Sta.**, *didynamous or* 2; **Ova.**, *sup.*, *4-lobed, becoming 4 seed-like monospermous fruit, nutlets.* Temp. Aro., Carmin., Stim. (vol. oil), Ton., Stomachic (bit. ext. prin.), Flavoring, Perfumery. MENTHA, HEDEOMA, SALVIA, SCUTELLARIA, MARRUBIUM.

DIVISION III. APETALOUS.

47. CHENOPODIACEÆ, kē-nō-pō-di-ā′sē-ē (L. *chenopodium* + *aceæ*, Gr. χήν, goose + πούς, foot, referring to shape of leaves), H., homely, succulent. **DISTING.—Flos.**, *ebracteated, minute, greenish*; **Ova.**, 1-*celled, forming* 1-*seeded utricle*. Disting. from Nyctaginaceæ by habit and ebracteated flos. Universal, saline places. Anthel., Antispas., Aro., Carmin., Stim. CHENOPODIUM.

48. PHYTOLACCACEÆ, fi′-tō-la-kā′sē-ē (L. *phytolacca* + *aceæ*, Gr. φυτόν, plant + Fr. *lac*, lake, alluding to crimson juice of berries), H. **DISTING.—Ova.**, *sup., many carpels in a ring, each with undivided style*, otherwise like Chenopodiaceæ; **Flos.**, *also similar*; **Fru.**, berry. Temp., Trop. Emet., Purg., Acrid principle destroyed by boiling in water. PHYTOLACCÆ.

49. POLYGONACEÆ, pŏl′-ĭ-gō-nā′-sē-ē (L. *polygonum* + *aceæ*, Gr. πολύς, many + γόνυ, knee, joint, from stem's numerous joints), H. or S. **DISTING.**—*Stem's many swollen joints, with ochriate stips. above each*; **Flos.**, *perfect, on jointed pedicels*; **Cal.**, *greenish*, 4-6, *petaloid*; **Ova.**, *sup.*, 1-celled; **Ovu.**, 1; **Sty.**, 2-3; **Sta.**, 6-9. Universal, Temp. Contains oxalic acid, Ast., Purg. RHEUM.

50. MYRISTICACEÆ, mi-ris-ti-kā′sē-ē (L. *myristica* + *aceæ*, Gr. μυριστικός, fit for anointing; μυρίζειν, anoint), T. **DISTING.—Flos.**, *diœcious, reg.*; **Cal.**, 3-*lobed*; **Fil.**, 3-12, *united*; **Ova.**, 1-celled; **Ovu.**, 1; **Les.**, *alternate*; **Fru.**, *succulent*. Trop. Aro. Seed (strongest), Bark, Pericarp Acrid. MYRISTICA, MACIS.

51. ARISTOLOCHIACEÆ, ar′-is-tō-lō-ki-ā′sē-ē (L. *aristolochia* + *aceæ*, Gr. ἄριστος, best + λοχεία, child-birth, its supposed medicinal qualities), H. or Climbing S. **DISTING.—Fru.**, *inf., cap., many-seeded*; **Sta.**, 6-12, epigynous; **Cal.**, *irreg., colored*; **Les.**, *cordate, entire, petioled*. Temp. Ton., Stim., Acrid (vol. oil, bit. princ.), Cures snake bites. SERPENTARIA.

52. PIPERACEÆ, pĭp-e-rā'sē-ē (L. *piper* + *aceæ*, fr. *pippul*, a Bengalese name, or *pepto*, to digest), H. or S., with jointed stems. **DISTING.—Ova.**, 3-5, somewhat united, 1-celled, 1 ovule; **Stig.**, 2-4; **Cal.**, *none*; **Flos.**, *naked, spiked*. Trop. Acrid, Pungent, Aro., Stim. (fruits, due to acrid vol. oil and resin), Nar., Ast., Feb. MATICO, CUBEBA, PIPER.

53. LAURINEÆ or **ACEÆ**, lâ-rā′sē-ē (L. *laurus* + *ineæ* or *aceæ*, Bay tree, fr. Celtic *blaur* (*laur*, the *b* dropped), signifying green, referring to plant's foliage), T. or S., Arom. **DISTING.—Les.**, *dotted*; **Flos.**, *polygamous*; **Cal.**, 4-6, *in 2 rows, petaloid*; **Anth.**, *opening by* 2-4 *uplifted valves*; **Ova.**, 1-celled; **Ovu.**, 1 in each cell; **Fru.**, drupe or baccate. Trop. Aro., Stim. (vol. oil), Nar., Ton., Feb., Ast., Timber. SASSAFRAS, CAMPHORA, CINNAMOMUM.

54. THYMELÆACEÆ, thim′-e-lē-ā′sē-ē [L. *thymelæa* + *aceæ*, Gr. θυμελαία, a plant; θύμος, thyme + ἐλαία, olive tree; θύμος, courage, referring to the reviving odor; or θύω, to perfume, being used in temples as incense), T. or S., with acrid, tough bark. **DISTING.—Cal.**, 4-5, *imbricated lobes, colored, radicle, sup.*; **Sta.**, *twice*; **Ova.**,

1-*celled*; **Ovu.**, 1; **Fru.**, *drupe*, *Anth. open longitudinally.* Trop. Nar., Poi. MEZEREUM.

55. SANTALACEÆ, san-ta-lā′sē-ē (L. *Santalum* + *aceæ*, fr. Persian name *Sandul*, useful), H., T. or S. **DISTING.—Ova.**, 1-*celled*, *inf.*; **Ovu.**, 1-2-3, *suspended*; **Anth.**, *on filament*; **Flos.**, *green*, 4-5*s*; **Cal.**, 4-5 valvate, Sup. Temp., Trop. Ast.; Se. Oily; Fru. edible. OL. SANTALI.

56. EUPHORBIACEÆ, ū-fôr-bĭ-ā′sē-ē (L. *euphorbia* + *aceæ*, Gr. Εὔφορβος, well-fed; εὖ, well + φέρβειν, feed, after Euphorbus, physician to Juba, King of Mauritania), T., S. or H., with milky, acrid juice. **DISTING.—Flos.**, *unisexual*; **Fru.**, tricoccous, 3-6 seeded capsule; **Ova.**, Sup. Temp., Trop. Emet., Purg., Diu., Rubef., Starchy food, Caoutchouc, Aro., Ton., Dyes, Wood, Poi. KAMALA, CASCARILLA, ELASTICA, STILLINGIA.

57. URTICACEÆ, ėr-tĭ-kā′sē-ē (L. *urtica* + *aceæ*, a nettle, fr. *uro*, *urere*, to burn; referring to its stinging or burning properties), H., S. or T., with watery juice. **DISTING.—Les.**, *with stinging glands*, *stip.*; **Flos.**, *unisexual*, *heads or catkins*; **Cal.**, free from 1-celled Ova. Universal. Yields fibres and stinging juice. ULMUS, CANNABIS INDICA, HUMULUS, LUPULINUM, FICUS.

58. BETULACEÆ, bet-ū-lā′sē-ē (L. *betula* + *aceæ*, fr. Celtic *betu*, the birch), T. or S. **DISTING.—Flos.**, *monœcious*, *catkins*; **Cal.**, *none*, instead have *scaly bracts*; **Sta.**, 2-4; **Ova.**, 2-celled; **Ovu.**, 2. Same as Cupuliferæ, Tribe 1, Betuleæ. OL. BETULÆ VOL.

59. JUGLANDACEÆ, jŭ-glan-dā′sē-ē (L. *Juglans* (*Jugland*) + *aceæ*, a walnut tree, fr. *Jovis-glans* = nut of Jove, Jupiter, referring to the fruit), T. **DISTING.—Les.**, *pinnate*, *exstip.*; **Flos.**, *monœcious*, *sterile in catkins*, *fertile in spikes*, both with Cal., 3-5; **Ova.**, 2-4 *celled*, Inf.; **Ovu.**, 1; **Fru.**, naked, *bony nut*. Temp. Cath., **Se.** edible, Oily, Timber. JUGLANS.

60. CUPULIFERÆ, kū-pū-lĭf′e-rē (L. *cupula*, little cup + *ferre*, to bear, referring to its fruit), T. or S. **DISTING.—Fru.**, *in capsule involucre*; **Flos.**, *monœcious*, *sterile in catkins*; **Sta.**, 10-20, *fertile in spikes*, 1-3, *or scaly catkins*, *involucre*; **Ova.**, *inf.*, 2-6 *celled*; **Ovu.**, 1-2 *in each cell.* Temp., Trop. Ast., **Se.** edible, Timber. QUERCUS, GALLA, CASTANEA.

61. SALICACEÆ, săl-ĭ-kā′sē-ē (L. *sali*(*x*)*c* + *aceæ*, willow, Celtic *sal*, near + *lis*, water, place of growth, or *salire*, to leap, its rapid growth), T. or S. **DISTING.—Flos.**, *diœcious*, *both kinds in catkins*, *no perianth*; **Sta.**, 2; + **Ova.**, 1-*celled*; **Fru.**, 2-4 *valved capsule*; **Se.**, *many*, *bearing dense hair at one end.* Temp. Ton., Ast., Feb., Stim., Timber, Baskets. SALICINUM.

SUB-CLASS II. GYMNOSPERMÆ.

62. CONIFERÆ, kō-nif′e-rē (L. fem. pl. of *conifer*, cone-bearing, *conus*, a cone + *ferre*, to bear, referring to the fruit), T. or S., resinous, evergreen. **DISTING.—Se.**, *naked*, 2; + **Flos.**, *monœcious*, *male in catkins*, *female in cones*; **Les.**, *needle-shaped*, *no perianth*; wood-cells have discoid markings. Temp.. Stim., Diu., Emmen., Anthel., Expect., Timber. SABINA.

CLASS II. MONOCOTYLEDONS.

63. **SCITAMINEÆ**, sit-a-min'ē-ē (L. *scitam(enta)*, delicacies, *scitus*, *sciscere*, clever, from its dainty aromatic products), H., aromatic. **DISTING.**—*Creeping rhizome*; **Les.**, *stalked*, *sheathing*; **Cal.** and **Cor.**, *distinct*, *each* 3; **Ova.**, *inf.*; **Se.**, *arillate*, embryo in canal, centre of Alb.; **Sta.**, 6, in 2 whorls, abortive. Trop. Stim., Aro. (res. + vol. oil), Stomachics, Starch. CARDAMOMUM, ZINGIBER.

64. **ORCHIDEÆ** or **ACEÆ**, ôr-kĭ-dā'sē-ē (L. *Orchi(s)d* + *eæ* or *aceæ*, Gr. ὄρχις, a testicle, named from shape of roots), H. or S., terrestrial and epiphytical. **DISTING.**—**Anth.**, 1 or 2, sessile, united to *Pi.*; **Flos.**, *irreg.*, *reptile-shape*, *perfect*; *Perianth*, 6, *in 2 whorls*, *petaloid*; **Ova.**, *inf.*; **Les.**, *sheathing*. Universal. Aro., Antispas., Nutrit., Aphrodisiac, Flavoring. VANILLA, CYPRIPEDIUM.

65. **IRIDEÆ** or **ACEÆ**, ĭr-ĭ-dā'sē-ē (L. *iris(s)d* + *eæ* or *aceæ*, Gr. ἶρι(ς)δ, a rainbow, goddess of, fr. *iris*, the eye, alluding to the bright and varied colored flowers), H., with bulbs, corms or rhizomes. **DISTING.**—**Les.**, *equitant* = *2-ranked*; **Flos.**, 6, *reg. or irreg.*, *perfect*, *petaloid*; **Ova.**, *inf.*, *3-celled*; **Sta**, 3, *distinct or monadelphous*; *Anth.*, *extrorse*, *open lengthwise*. Temp., Trop. Purg., Emet., Antispas., Carmin., Poi. IRIS, CROCUS.

66. **LILIACEÆ**, lĭl-ĭ-ā'sē-ē (L. *lilium* + *aceæ*, a lily, fr. Celtic *li*, whiteness, alluding to beautiful white flowers of original species), H., S. or T., with bulbs, rhizomes, tubers or fibrous roots. **DISTING.**—**Flos.**, reg., sym., 6-androus; *Perianth*, *non-glumacious*, petaloid; **Ova.**, *sup.*, *3-celled*; **Anth.**, *2-celled*; **Fru.**, many or few-seeded, pod or berry. Temp., Trop. Purg., Emet., Diu., Diaph., Stim., Ast., Acrid, Fibres, Food, Condiments. SARSAPARILLA, SCILLA, ALLIUM, CONVALLARIA, ALOE, COLCHICI, VERATRUM.

67. **AROIDEÆ** or **ARACEÆ**, a-rā'sē-ē (L. *arum* or *aron* + *aceæ*, Gr. ἄρον, the wake-robin, Egyptian word), H. or S., acrid juice, tubers, corms, rhizomes. **DISTING.**—**Les.**, *veiny*, petioled; **Flos.**, *perfect or monœcious*, *spadix with spathe*, no perianth; **Fru.**, *succulent*. Terra or marsh plants. Trop., Temp. Aro., Stim., Expect., Antispas., Diaph. CALAMUS.

68. **GRAMINEÆ** or **ACEÆ**, grăm-ĭ-nā'sē-ē (L. fem. pl. of *gramineus*, of or pertaining to grass; *gramen*, grass), H. or S. Largest endogenous order save Orchidaceæ. **DISTING.**—*Stems*, *hollow*, *jointed*; **Les.**, *alt.*, *2-ranked*, *sheaths split opp. blade*; *perianth*, *none*, *glumes in pairs*; **Anth.**, *versatile*; **Fru.**, *caryopsis*; **Ova.**, Sup. Universal. Purg., Poi., Cereals, Fodder. ZEA, TRITICUM, AMYLUM.

SERIES II. CRYPTOGAMOUS, SUB-CLASS I. PTERIDOPHYTES.

69. **FILICES**, fil'i-sēz (L. pl. of *filix*, a fern; Skt. *parna*, wing, leaf; Gr. πτερόν), H. **DISTING.**—**Les.**, = *fronds*, *spores one kind*, *cases on back or margin of fronds*, *circinate in vernation*. Universal. Bit., Ast., Ton., Anthel., Aro., Mucilage. ASPIDIUM.

70. **LYCOPODIACEÆ**, lī-kŏ-pō-di-ā'sē-ē (L. *lycopodium* + *aceæ*, Gr. λύκος, a wolf + πούς, foot, appearance of the shoots), H., resemble

mosses. **DISTING.**—*Spores* yellow, solitary in axils of leaves, 2-3 valved, low, long-stemmed, moss-like evergreens; **Les.**, small, 4-16 ranks; *Sporangia*, 1-3 celled. Universal. Emet., Purg., Aphro., Acrid prin., Poi. LYCOPODIUM.

SUB-CLASS II. THALLOPHYTES(A).

71. **FUNGI**, fun′ji (L. *fungus*, a mushroom; Gr. σφόγγος, a sponge, from the resemblance). **DISTING.**—*Chlorophyll, none.* Are soft, hard, fibrous, gelatinous, fleshy or leathery, rarely grow in water. Those edible growing in dry, airy places, are white, do not change color, odor and taste pleasant; those poisonous just the opposite. ERGOTA.

72. **LICHENES**, lī-kē′nēz (L. *lichen*, Gr. λειχήν, a tree moss, λείχειν, lick). **DISTING.**—Perennial plants, resemble Fungi, but cells firm and dry, have chlorophyll, colored gray, brown, green, blackish, on barks of trees, walls, palings, stones. Universal. Nutri., Starchy, Demul., Ton., Ast., Aro., Dyes. CETRARIA.

73. **ALGÆ**, al′jē (L. pl. *alga*, seaweed). Parenchymatous plants. Grow in fresh or salt water, or moist places; color, green, rose or brownish. Universal. Nutri., Demul., Alt. CHONDRUS.

THE GREEK ALPHABET.

A	α	a	Alpha.	N	ν	n	Nu.
B	β	b	Bēta.	Ξ	ξ	x	Xi.
Γ	γ	g	Gamma.	O	ο	o short	Omīcron.
Δ	δ	d	Delta.	Π	π	p	Pi.
E	ε	e short	Epsīlon.	P	ρ	r	Rho.
Z	ζ	z	Zēta.	Σ	σ s	s	Sigma.
H	η	e long	Eta.	T	τ	t	Tau.
Θ	θ ϑ	th	Thēta.	Υ	υ	u	Upsīlon.
I	ι	i	Iota.	Φ	φ	ph	Phi.
K	κ	k	Kappa.	X	χ	ch	Chi.
Λ	λ	l	Lambda.	Ψ	ψ	ps	Psi.
M	μ	m	Mu.	Ω	ω	o long	Omĕga.

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